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AVIATION AND COSMONAUTICS

No 4, April 1990

Poor-Visibility and Night Guided-Weapons Delivery

90SV0004A Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 4, Apr 90 (signed to press 28 Feb 90) pp 4-5

[Article, published under the heading "Combat Training: Viewpoints, Suggestions," by Military Pilot 1st Class Col V. Bragin, candidate of military sciences, docent: "In More Complex Conditions"]

[Text] Modern bombers, fighter-bombers, and ground-attack aircraft are armed with guided weapons in various modifications, with laser and TV seekers, and particularly guided missiles and "smart" bombs. When these weapons are used, strike aircraft have considerably greater capabilities to destroy enemy targets.

The experience of local wars and armed conflicts indicates, however, that guided weapons of this category have been employed for the most part during daylight in VFR conditions, extremely rarely at night with target illumination, and they have been employed practically not at all in conditions of limited visibility. In the two latter instances this has been due to difficulty in visual target search and tracking with the laser and TV target engagement system's video monitoring device, as well as very frequently the impossibility of strike delivery due to target detection after passing the "smart" bomb release point or missile launch point. For this reason the search for tactics and modes of actions involving the employment of guided weapons in conditions of limited visibility and poor light conditions constitutes an urgent problem for frontal aviation strike aircraft.

Combined employment by aircrews of targeting radar (RPO), sighting optics (PPV), and laser and TV weapon sights can be considered one focal area in the development of tactics, while combined operations by aircraft elements of different types can be considered a focal area in development of modes of actions. The former presumes that when aiming, the RPO, PPV, and LTPS crosshair reticles are placed on the same point. Superimposition error should not exceed 4 minutes of angle. Then, after "referencing" with the RPO or PPV and switching on the optical laser (OKG), the laser beam is directed to the target and the LTPS will "illuminate" it, following the target with sighting reticle and operating either in "program-corrected" tracking (PKS) or automatic correction tracking (AKS) mode. This enables the crew to effect guided weapon launch (release) with target engagement by RPO (PPV) until the target is detected with the LTPS, or without a target image on the VKU display with an inadequate light level.

Employment of guided weapons with target engagement by RPO is possible if the aircraft remains within the target engagement system search sector right up to guidance termination. Analysis of RPO and LTPS zones of visibility and areas of possible missile launch and guided bomb release (see Figure 1 in following article) indicates that missile guidance and launch is not assured at low altitudes and at close range. Optimal conditions are range in excess of 5.5 km and altitude from 200 to 1,500 meters. "Smart" bomb guidance, however, is performed throughout the range of release heights. The seeker should lock on the laser spot no later than 10-11 seconds before burst.

Tactics have been devised in conformity with the above-stated possibilities of combined employment of targeting and target engagement systems, for delivery of strikes by frontal-aviation bombers delivering "smart" bombs, when the target is detected with the LTPS following bomb release using the RPO. When striking an airfield, for example, when the strike aircraft approaches to a distance of 20-25 km, it climbs to bomb release height, aims to the runway (or to an aiming-off point) by radar, releases the bomb and simultaneously switches on the optical laser (see Figure 2 in following article). The LTPS operates in PKS or AKS mode. When the target appears on the VKU, the systems operator, with the MUP [expansion unknown], places the crosshair reticle on the target and holds it there, continuing bomb guidance right up to the moment of burst.

If strike target light level and contrast are insufficient for detection with the LTPS, particularly at night, the bomber crew can employ missiles with laser seeker, aiming only with RPO (see Figure 3 in following article). In this case missiles are launched from a shallow dive at long range and from a height of 2,500-3,000 meters, with LTPS switched on. The RPO crosshair reticle is held precisely on the target until detonation, while guidance is by optical laser, but with an accuracy determined by aiming system alignment error.

Guided bombs, however, cannot be employed in these conditions or when released from within or above clouds from a single aircraft, since at a certain moment the target leaves the RPO field of view, and LTPS target tracking breaks. Illumination of the target with an optical laser carried by another aircraft is a solution to the problem, however (see AVIATSIYA I KOSMONAVTIKA, No 2, 1990). The other aircraft should reach the laser switch-on point 10-11 seconds before bomb detonation.

With this strike delivery variation, the lead aircraft drops the guided bomb, while the wingman illuminates the target. Both aircraft employ radar aiming. In order to reach the optical-laser switch-on point at the proper time, the wingman follows behind the leader at a distance of deltaD, holding this distance using the RSBN-6S [local radio navigation system] in intercept mode. The distance is calculated as follows: deltaD=$V_{wi}T_{gb}+D_{rmin}-A+2s_{d\ rsbn}$, where V_{wi}—airspeed of wingman; T_{gb} and A—guided bomb time of fall and carry; D_{rmin}—minimum range at which target is visible to wingman in

radar bombsight (N_p+1 km); $s_{d\ rsbn}$—error in maintaining distance between aircraft with RSBN-6S.

The wingman should proceed on final target heading under cloud cover. Cloud bases should not be below 800-900 meters in order to ensure bomb guidance in the terminal phase, during the last 10-11 seconds before burst.

Fighter-bombers and ground-attack aircraft which are not equipped with radar target engagement systems employ guided weapons at night principally on illuminated targets. Figuring that intensity of illumination should be not less than 2,000 lux, even with visibility of 10 km and more it will be necessary to drop up to 30-50 illumination flares. They form a masking background, however, in conditions of obscuring dust and smoke, making visual detection of the target difficult and at times impossible.

Capabilities to employ guided weapons are significantly enhanced if they carry a passive TV correlation seeker. Under these conditions guided bombs can be employed with a terrain illumination level of not less than 40-50 lux. This level is present at dusk, while during hours of darkness sufficient intensity of illumination can be produced with from 10 to 12 parachute flares (with visibility (meteorological) of 10 km), which will require two or three illumination aircraft. Targets marked in advance with aircraft-dropped parachute signal flares can also be hit with guided bombs with a correlation-type seeker. For this it will be necessary to establish in the target area a cluster consisting of at least three points of illumination, taking into consideration the specific operating features of the guidance system.

If the level of illumination at dusk and at night is sufficient or if the target is illuminated, one can employ guided missiles with laser seeker against it, with an optical target engagement system. Following visual detection of the target, the pilot places the crosshair reticle on it and "references the target"; he then keeps the aiming mark on it. When the optical laser is switched on, the laser beam will illuminate the target and guide the missile, but with an error determined by optical sight and LTPS adjustment accuracy. A strike using this method will require an illumination aircraft and a strike aircraft at night, and strike aircraft alone at dusk.

Employment of guided weapons by aircraft from different frontal-aviation components is also possible in combined missions. Bombers equipped with the most accurate integrated targeting and navigation system should fly as mission leaders for the other strike elements, marking or illuminating specified targets with RPO target engagement, as well as providing guided weapons guidance with LTPS. The fighter-bombers and ground-attack aircraft will release (launch) their guided weapons at the leaders' command at an illuminated or marked target. Depending on the situation, bombers can function both as leaders and can concomitantly carry out their primary mission.

Figure 4 (see following article) shows a variation of strike on an enemy airfield by multiple-component forces. The bomber elements are headed for assigned targets located at operational depth, but they are routed across the fighter-bombers' target. All elements in a common formation maintain visual contact and are escorted by jammer aircraft and fighters. Upon approaching the target airfield, the bomber flight climbs to 3,000 meters and opens up to lateral spacings of 600-800 meters. The fighter-bombers attach to their leaders in pairs. The bomber-leaders place their radar aiming point on the runway and give the command to the other aircraft to release their guided bombs. After this the fighter-bombers descend to low level and return to base, while the bombers continue on to their target area.

The second flight of bombers, trailing the first flight by distance deltaD, maintained by RSBN-6S or visually, also place their radar aiming point on the runway and, with switched-on optical laser, guide the bombs released by the fighter-bombers. Four target damage areas form on the runway, and the airfield is knocked out of operation. At the moment of bomb burst the bombers break from the target and proceed to their own targets. This procedure of delivering a strike by multiple-component forces makes it possible for fighter-bombers to employ guided weapons with limited visibility and illumination. In addition, the force of supporting aircraft is reduced, and when elements fly in a common formation, favorable conditions are ensured for air defense penetration.

LTPS, PPV, and RPO adjustment errors will affect accuracy of employment of laser-guided weapons in the above strike variations (see table).

Table

	Weapon Guidance Linear Error (in plane of figure), at Launch (Release) Distance, m				
Sight Adjustment Error, minutes of angle	1000	2000	3000	4000	5000
2	0.6	1.2	1.7	2.3	2.9
4	1.2	2.3	3.5	4.6	5.8

Depending on range of launch (release), probable error can increase by a factor of 1.5 to 2 in comparison with standard errors for an LTPS. In any case, however, they remain smaller by a factor of 5 to 10 than in the case of unguided weapons. Nevertheless all sighting systems should be aligned as accurately as possible.

In order to confirm the above, calculations were made to determine the required forces to destroy a river crossing facility in a night strike. Frontal-aviation bombers employ guided missiles (LTPS, RPO, and LTPS target engagement) or high explosive fragmentation bombs (RPO aiming), while the fighter-bombers drop bombs (optical bombsight aiming only).

Based on results, effectiveness of strike aircraft actions with guided weapons delivery and combined employment of sighting systems proves to be half that when direct LTPS target engagement is employed, but effectiveness is five to nine times that achieved with gravity bombs. It is therefore advisable to test the proposed tactics and modes of frontal-aviation actions during limited visibility and at night by means of an in-air experiment, to refine and detail the manner and procedure of execution, and extensively to adopt these tactics in the practical combat training of Air Force line units.

Limited-Visibility and Night Guided-Weapons Strike Delivery Diagrams

90SV0004B Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 4, Apr 90 (signed to press 28 Feb 90) pp 24-25

[Annotated diagrams: "With Limited Visibility and at Night"]

[Text] [See preceding article for expansion of abbreviations]

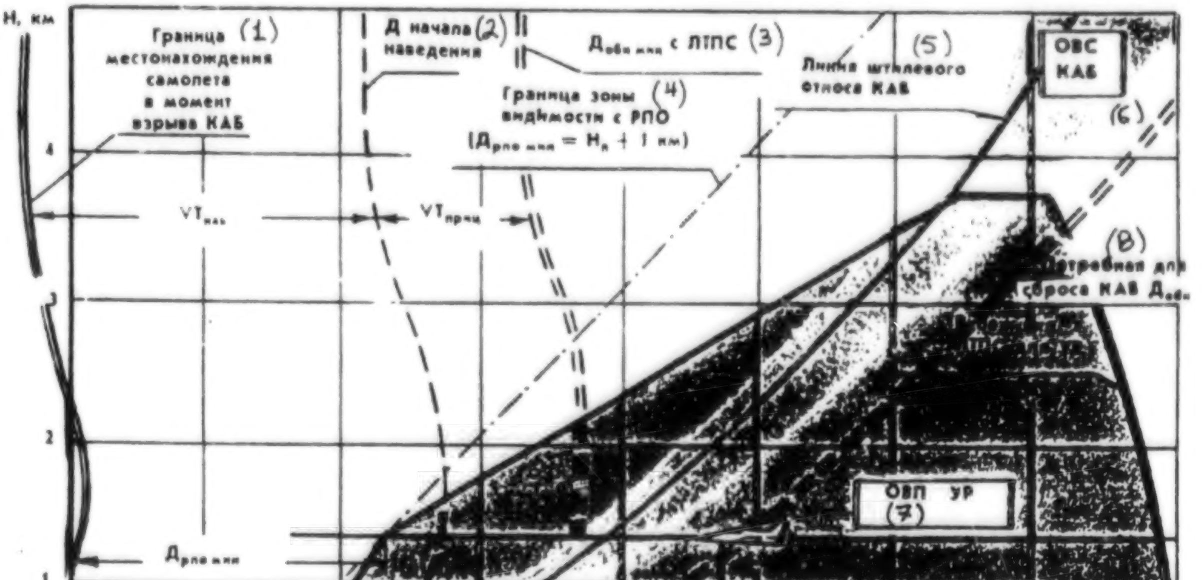


Figure 1. Boundaries of Zones of Visibility With RPO and LTPS, Guided Missile Launch Range and Guided Bomb Release Range Envelopes.

Key: 1. Boundary of aircraft location at moment of guided bomb detonation 2. Commencement of guidance 3. From LTPS 4. Boundary of zone of visibility with RPO 5. Guided bomb carry path, no-wind conditions 6. Guided bomb release range envelope 7. Guided missile launch range envelope 8. Required for guided bomb release with LTPS 9. LTPS switch-on point for guided missile

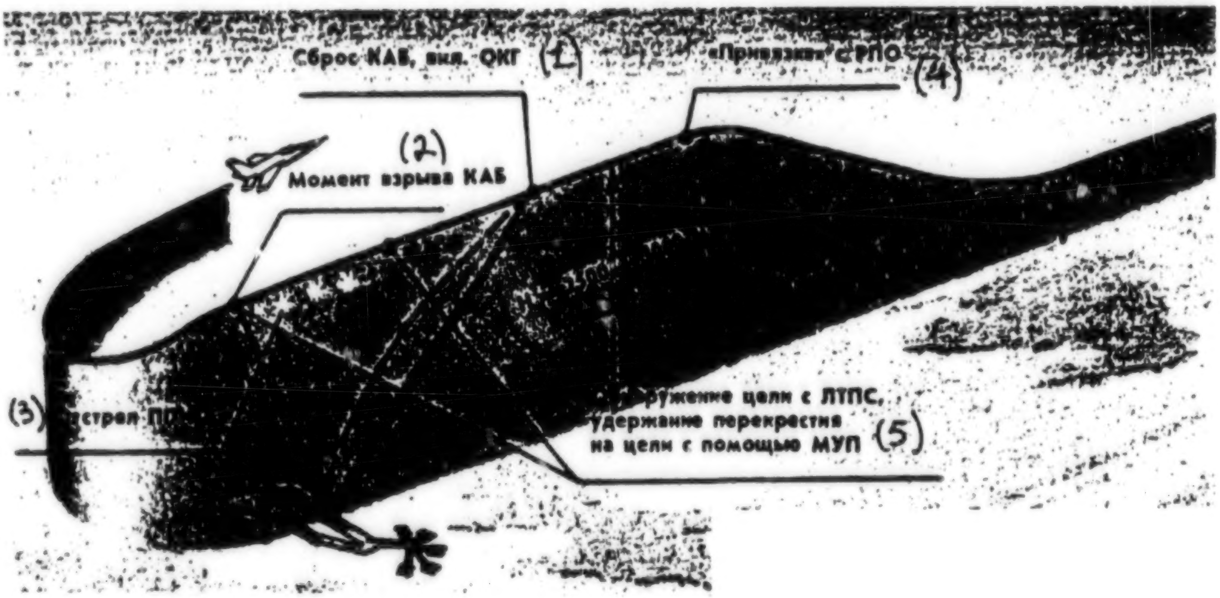


Figure 2. Employment of Guided Bombs Against Airfield With Limited Visibility, With RPO Aiming

Key: 1. Release guided bomb, switch on optical laser 2. Moment of bomb detonation 3. Release flares 4. "Referencing" with RPO 5. Target detection with LTPS, holding crosshair reticle on target with MUP

	H, m		
Guided Bomb Release Parameters	3200	4000	4800
Time of fall, s	26.74	30.09	33.15
Time of guided flight, s	10.64	11.09	11.15

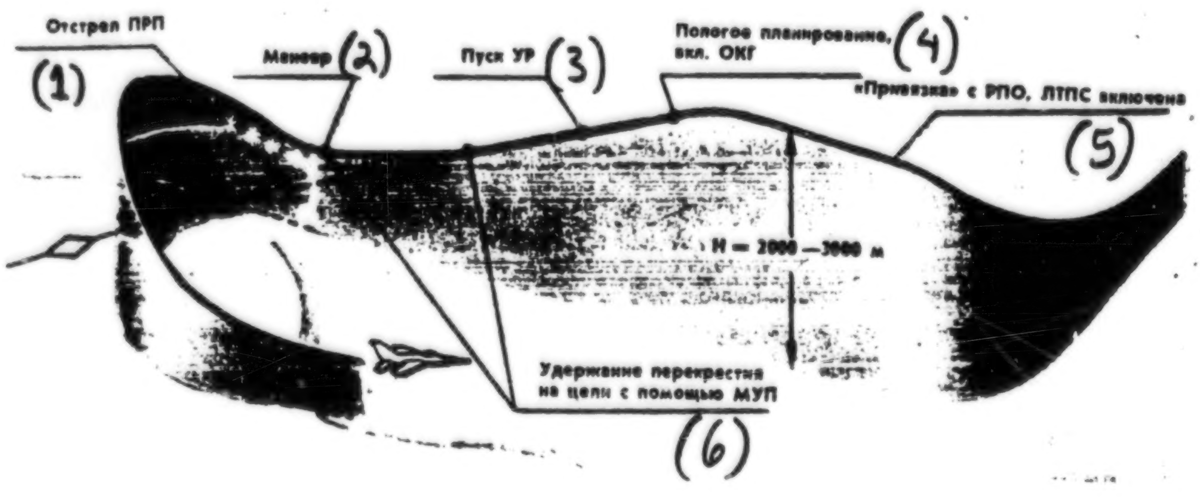


Figure 3. Employment of Guided Missiles Against a Bridge at Night, Aiming With RPO

Key: 1. Release flares 2. Maneuver 3. Launch missiles 4. Shallow glide, switch on optical laser 5. "Referencing" with RPO, LTPS switched on 6. Holding crosshair reticle on target with MUP

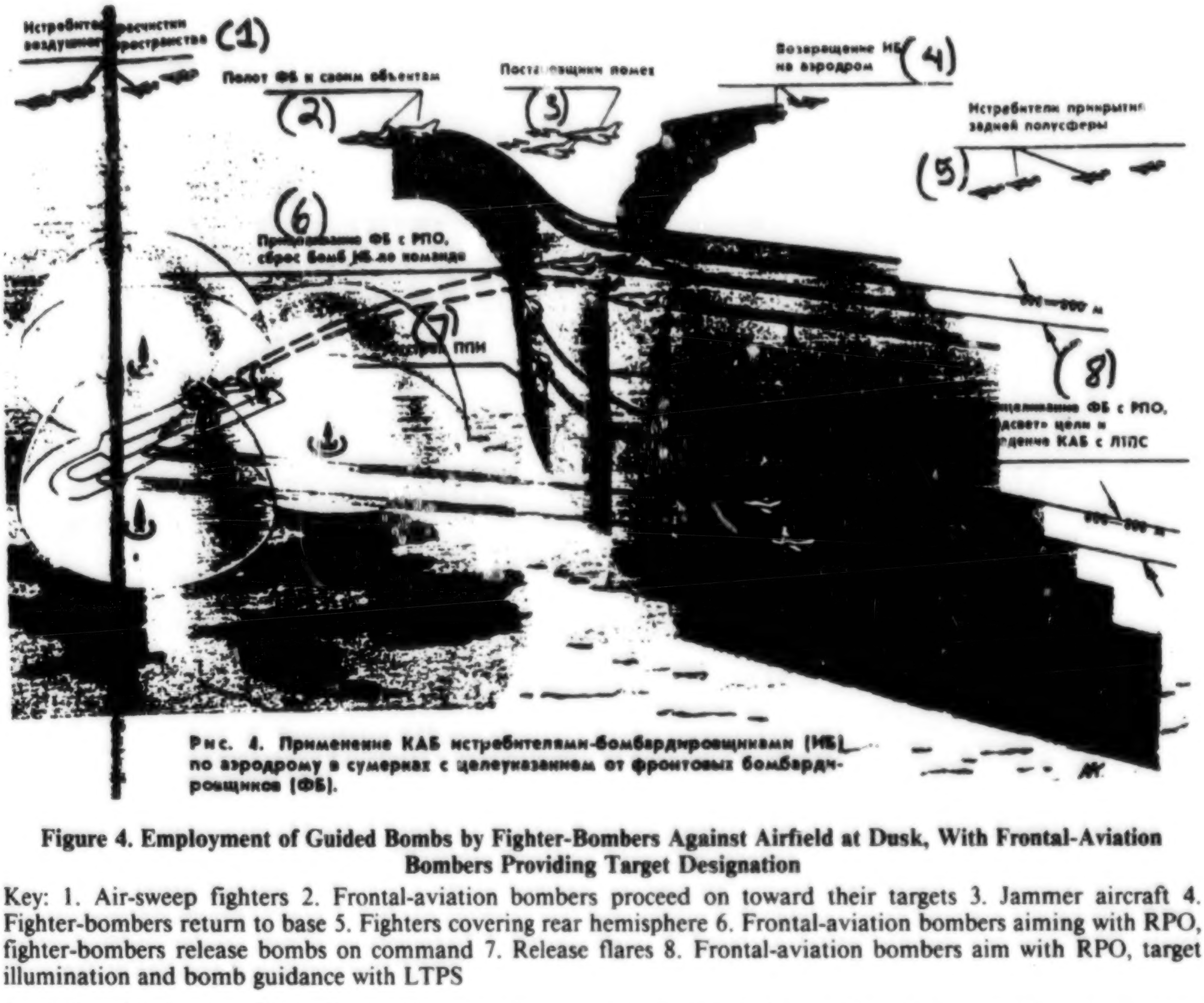


Рис. 4. Применение КАБ истребителями-бомбардировщиками (ИБ) по аэродрому в сумерках с целеуказанием от фронтовых бомбардировщиков (ФБ).

Figure 4. Employment of Guided Bombs by Fighter-Bombers Against Airfield at Dusk, With Frontal-Aviation Bombers Providing Target Designation

Key: 1. Air-sweep fighters 2. Frontal-aviation bombers proceed on toward their targets 3. Jammer aircraft 4. Fighter-bombers return to base 5. Fighters covering rear hemisphere 6. Frontal-aviation bombers aiming with RPO, fighter-bombers release bombs on command 7. Release flares 8. Frontal-aviation bombers aim with RPO, target illumination and bomb guidance with LTPS

Preparing Helicopter Pilots for Violent Combat Maneuvering

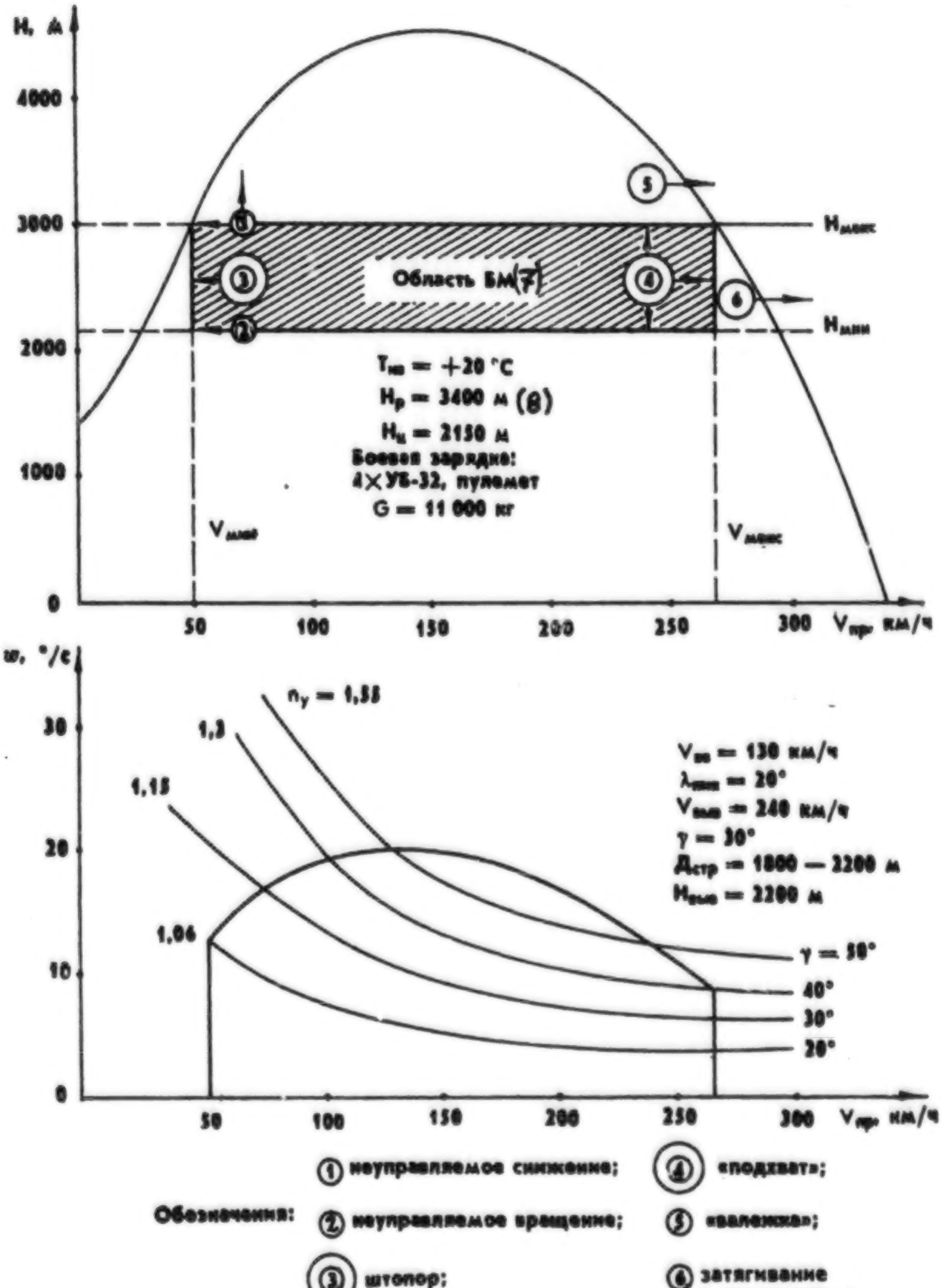
90SV0004C Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 4, Apr 90 (signed to press 28 Feb 90) pp 6-7

[Article, published under the heading "Into the Military Pilot's Arsenal," by Military Pilot 1st Class Col M. Yelkin, candidate of military sciences, docent: "Evasive Maneuver: Sober Calculation or Desperation?"]

[Text] During the war in Afghanistan a number of deficiencies were revealed in the performance of army aviation aircrews. These shortcomings involved the theoretical, practical, and psychological aspects of flight personnel training and led to an increase in the number of gross errors and unwarranted losses.

One of the factors involved was worsening of helicopter tactical performance in conditions of high-elevation terrain and high temperatures, especially altitude, speed, and maneuver performance. Pilots frequently were unable to determine their helicopter's actual capabilities and flew them out of their performance envelope. Unintentional entry into conditions for spontaneous descent and rotation, spin, G force "pickup," and involuntary banking are consequences of prohibitory regulations and restrictions existing within the army aviation aircrew combat training system. If a pilot has not previously mastered flight at extremely low level and high altitudes, and if he has not flown the helicopter at speeds and load factors close to critical, as well as in the most flight-critical conditions, one can scarcely expect flight safety in a combat environment.

One can fly an aircraft with sure hand and make intelligent decisions in combat only when one has had the opportunity to feel in a practical way the effect of the most varied factors on a helicopter's tactical performance characteristics. Aircrews should learn the art of risk on training flights. Only then will combat effectiveness and safety not mutually exclude one another but will supplement each other, ensuring success. Only in this case will pilots develop psychological stability when faced with emergency situations, including deliberately flying critically close to the edge of the performance envelope.



Key: 1. Spontaneous descent 2. Spontaneous rotation 3. Spin 4. G force "pickup" 5. Involuntary banking 6. Pitchdown into a dive 7. Combat maneuvering envelope 8. Ordnance loadout: 4 x UB-32, machinegun

Hero of the Soviet Union Maj Gen Avn V. Pavlov, for example, was the first (perhaps the first in the world) in combat conditions, risking being shot down, to carry off an Mi-8 on a sling from his own Mi-8, in full view of a perplexed enemy. Col F. Shagaleyev, as he was rescuing some air assault troops under ambush, was forced to land on a site which barely accommodated the helicopter but did not permit him to swing around 180 degrees for takeoff. The pilot yanked away from the cliff face, pulled back on the cyclic stick, and plunged tail-first into the gorge. As he was falling he swung the helicopter around and pulled it out of the dive. As a result of these actions, he saved his crew and the air assault troopers from certain death. The entire maneuver was executed in precise conformity with the laws of aerodynamics, although in a very unusual manner.

Hero of the Soviet Union Col V. Pismennyy as well as Majs V. Seleznev and V. Sharnauskas, finding themselves

in an extreme emergency, deliberately performed the prohibited "vortex ring" maneuver in order to descend rapidly in a limited space, seeing that as the only possible way of accomplishing the mission. After this, they began teaching it to their men. Hero of the Soviet Union Maj S. Filipchenkov was flying a mission to knock out a target situated on a small island on the floor of a gorge, flying number three position. Two crews, who had chosen to attack along the river, had already been shot down. Filipchenkov came in from across the gorge and, going into a dive, hit the target. Realizing that he would not be able to recover without striking the mountainslope, he intentionally put his helicopter into a G force "pickup". The helicopter zoomed into a steep climb and avoided impact. Filipchenkov smoothly brought it back from the critical edge of the envelope and returned safely to base.

Other incidents have also occurred, however. A lack of experience in flying close to the edge of the performance envelope and lack of knowledge of the boundaries of the possible in combat conditions would engender a psychological uncertainty in flight personnel and would lead to gross errors. For example, when their helicopter was in danger of taking a hit from a shoulder-fired antiaircraft missile, some pilots would execute dangerous evasive maneuvers: vertical and horizontal S-turns with bank angles up to 50 degrees and pitch angles up to 30-40 degrees, extremely rapidly, which did not always have a safe outcome.

Why is it that in combat pilots proved to be not fully prepared? We see the reason for this in the very combat training system, about the radical alteration of which there has been so much discussion at all levels, but so little action. In fact, that which the pilot should be able to do—construct simulations and select sensible combat maneuvers—is acquired primarily at the academy. But academy graduates who took part in combat operations did not have the opportunity to pass on their knowledge to their men, since line units are poorly equipped with computer hardware, the requisite textbooks and manuals, studies and workups, etc. The fact that pilots rarely consult with aerodynamicists, psychologists, and other specialist personnel in mastering complex flight maneuvers indicates that they underestimate forthcoming difficulties and training deficiencies at service schools, where one is not fully taught to link theory together with practical experience, independence and initiative.

Advance preparation of strike or combat-engagement models plays an important role in reducing the probability that a helicopter will fly out of its envelope and experience adverse phenomena in the process of combat maneuvering. In constructing such models one must first evaluate the helicopter's altitude and speed performance characteristics, plotting a graph indicating the operating range of altitudes and airspeeds (see diagram). One then isolates within the diagram a combat maneuvering area in which the assigned combat mission should be performed. Its lower boundary (H_{min}) is determined by the target's elevation or altitude above sea level, while the upper boundary (H_{max}) is determined by the maximum altitude in the process of maneuvering. The minimum (V_{min}) and maximum (V_{max}) airspeed boundaries are established according to the points of intersection of the upper boundary of the combat maneuvering area with the curve determined by the helicopter's operating altitude and airspeed envelope.

After this, maximum maneuver capabilities are determined, which are indicated on the rate of turn graph (omega) in relation to airspeed and load factor during maneuver (V, n_y). Maximum G-load values for a specific helicopter can be determined from the operating manual or by measuring corresponding bank angles ($gamma_{max}$) during horizontal maneuvering at speeds of 100, 150, 200, 250 km/h etc. Hazardous phenomena occurrence regions are also placed on these graphs (G force "pickup", spin, etc), as well as combat maneuvering boundary conditions as regards airspeed on entry (V_{BB}) and recovery (V_{BbIB}), recovery altitude (H_{BbIB}) and bank (gamma).

The information obtained in this manner enables one to construct simplified models of target strike delivery within the limits of a helicopter's altitude, airspeed, and G-load capabilities, as well as to analyze various flight situations. More detailed simulation is performed only with a computer.

It is possible to raise pilot training and proficiency for combat maneuvering to a qualitatively new level only by radically altering the combat training system proper. This requires a combined approach, which prescribes what flight and command personnel should study and how they should study it at all stages: "DOSAAF - service school - specialized training center - line unit - service academy," in order to be fully prepared. I would like emphatically to draw attention to this problem by army aviation and Air Force authorities, on whom its resolution primarily depends.

Pilot Motivation Discussed

90SV0004D Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 4, Apr 90 (signed to press 28 Feb 90) pp 8-9

[Article, published under the heading "Flight Safety: Experience, Analysis, Problems," by Lt Col Med Serv A. Medenkov, candidate of psychological sciences, and Lt Col Med Serv V. Savchenko, candidate of medical sciences: "What Motivates Flight Activity?"]

[Text] Motives for flight activity.... Their structure is not as simple as it sometimes seems. It will happen that a single component—the desire to fly—takes some time to become a primary component. Nor does it always retain first place in the process of flying work. It is therefore very important to know the structure of a pilot's motives and the needs on which they are based, to be able to discern the leading, principal motives among them, as well as those factors which negatively affect the forming of professionally significant motivation. Without this it

is impossible to determine priority areas of psychosocial support and backup of pilot activeness.

This is also necessary in order to intervene in a prompt and timely manner in the process of replacement of positive motives with negative ones which are unfavorable for flight activity. Such a replacement is reason for concern from the standpoint of maintaining professional reliability, from the standpoint of ensuring flight safety, and as regards maintaining the physical and emotional health of the military pilot.

What do we encounter when analyzing the structure of motives for flight activity?

The primary motive among student pilots is the desire to become a pilot, to learn to fly a modern aircraft, to master a difficult, manly and fascinating profession, which requires not only good physical and mental health but also profound knowledge in many areas of modern science and technology. Obviously the brighter the image of this dream and the more clearly-defined the milestones of its attainment, the more effective the result is. The dream not only summons the cadet toward the goal, forms and shapes his needs, but also enables him to overcome difficulties which arise. The more clearly a cadet visualizes his future profession and specific individuals who represent for him a possible example in career advance, the stronger will be the mobilizing effect of this dream. It is very important here that such an example not be a random or chance example—negative, or on the contrary, concentrating only optimistic hopes and expectations. The consequences can be unfortunate in both instances.

The goals, motives, methods and results of a cadet's curricular activities are closely linked by an aggregate of personality and character traits. An important role in forming motives is played by the cadets' needs and demands. A dominant element in this is assessment of one's proficiency by one's instructor and fellow cadets. It is therefore not surprising that the desire to perform a flight assignment well, especially those elements which are visually observable by tower personnel and one's comrades, is considered a principal motive in the process of a flight operations shift.

The desire to avoid failure is also considered a primary motive. For example, a large percentage of trainees are distinguished at the beginning of flight training by the desire not to be written up in the flight operations officer's log for a poor landing. Such motivation is noted in 18.9 percent of second-year cadets. The figure is 9.7 and 8.6 percent respectively for third-year and fourth-year cadets.

The unsatisfactory nature of a motive for achieving success in the process of primary flight training frequently leads to an endeavor by a cadet to attract attention by means of a bold, daring action, which frequently ends in... dismissal from school. This is quite regrettable, for in many cases skilled psychological support or adjustment could preserve for military aviation dozens of young men who are capable of ultimately developing into fine military pilots.

Teaching faculty, commanders, and instructors should bear in mind that the motives which form on the basis of a person's vitally important needs are rarely dominant in pilot cadets, although they are primary in their overall structure. Motives of a social nature emerge, consolidate and interact with one another on the basis of these other motives. It is true that they frequently become primary, and sometimes even assume a leading position. This frequently causes neglect of social and cultural problems, problems pertaining to daily life, discomfort in organization of leisure time, and deficiencies in forming moral, ethical, and aesthetic criteria of conduct and behavior.

At Air Force schools cadets solo for the first time in their lives. They experience thereby a particular need for psychologically skilled direction and leadership. A great deal in this area unquestionably depends on the instructor pilot who, while teaching the pilot cadet to fly, also forms and shapes his personality and character. Presenting a realistic picture of the life of a pilot and acquainting his charges with the external appearance and inner content of this life, the instructor himself must be confident that the true countenance of the dream is in fact attractive, and he must do everything in a practical manner to ensure that he maximally corresponds to that position of military pilot in the social structure of society which the military pilot deserves.

Attainment of professional expertise is the leading motive in fledgling pilots. Flying labor and the need to master new aircraft and methods of their employment are transformed into an airman's inner need to make his contribution toward performance of the tasks facing the Air Force unit. This is achieved by satisfying need both for community recognition and for subsequent career advancement.

The clear-cut directional thrust of a young military pilot toward increasing his job proficiency helps him successfully overcome the various life's problems he encounters.

The young pilot is of course not guaranteed against psychological or emotional trauma. It is rather the opposite: flying labor, especially during the period of becoming a pilot, is fraught with psychological conflicts which diminish motivation. Unfortunately they are not always resolved favorably for a pilot's psychological or emotional status. Who will help him during difficult days of mental and emotional stress? At the present time psychologists are not included within the table of organization of Air Force units. One must therefore learn to live with the regrettable situation where pilots with poor motivation commit 22.8 percent more mistakes (in comparison with those who are satisfied with their professional status).

Studies show that the reasons for many conflicts lie not so much in the personalities and individual characteristics of flight and leader personnel as in problems of the pilot's social and living conditions. Nevertheless the idea of radical change in the flight activity regimen is gaining recognition with great difficulty, and problems are being resolved very slowly in the area of organizing family leisure and recreation for Air Force personnel, job

assignment after being grounded from flight duty for reasons of health, and provision of housing.

Military people have a deep-rooted notion that discharge to reserve status means being thrown out onto the trash heap of used-up human material. People develop uncertainty about and loss of confidence in the future. Instances of inefficient loss of flight personnel time waiting for transportation, weather, and departure clearance have a deleterious effect.

And how about shortcomings and deficiencies in organization of a non-flying workday? Pilots place these first among several dozen factors which negatively affect job motivation. A pilot is sometimes powerless in the face of numerous rough spots in his job activities. As a rule that which is reasonably desired does not coincide with possibilities. This frequently serves as a primary cause of discoordination and mismatch, which can have a psychologically damaging effect. This results in a situation which fosters the occurrence of psychoneurological ailments.

These conclusions are backed up by the results of studies. Within a group of "dissatisfied" pilots, diagnoses of a psychoneurological nature account for 40 percent of all ailments. Another reason this happens is the fact that a "sword of culpability" for an air mishap or a mishap-threatening incident continues to hang over the pilot's head. It is considered that human error is at fault in 60-80 percent of such incidents.

And yet 50-70 percent of flight personnel errors are due to inadequate consideration of the human factor when designing aircraft, cockpit equipment and layout, information display devices and controls. As a result only a certain percentage of errors take place due to deficiencies in level of proficiency, in development of professionally important qualities, and in developing the requisite character traits: a sense of responsibility, discipline, etc. But even in this case we are confident that nobody will be so bold as to claim that the reasons for this are not connected with poor motivation and with inadequate directional thrust toward flight activity.

Essentially aircrew errors are in large measure a consequence of loss of interest in flying. In such a case, who is actually to blame for a mishap? Even if it is a mishap caused by incorrect, belated, or less-than-optimal actions by a pilot who is indifferent to the results of his actions, who is more concerned with problems on the job and conflict at home or with a superior....

To allow a person to fly who has lost interest in flying means acting with no less and perhaps even greater irresponsibility than the pilot, who frequently fails to perceive the change that is taking place in himself. Doubts about the correctness of his career choice continue to gnaw away at a pilot, and an insidious, destructive action is already taking place. This is when it is necessary to help him revive his confidence, to show him his real prospects, which can return his optimism and purposefulness.

We feel that particular responsibility lies with those whose job responsibilities include concerning themselves with the pilot's social well-being, his living conditions, morale and the psychological atmosphere in the unit, with organization of flight personnel rest and leisure time, particularly family time (and not only in order to relieve emotional stress but also to ensure psychological stability and well-being in the family).

Particular alarm is evoked by shortcomings in the forming of pilot psychological reliability in the course of preflight training. The problem of providing this process with everything required continues to be of critical importance. While specialist personnel still attempt to respond to the question: "What should be taught and how?", nowadays it is hardly possible to find a simple and unequivocal answer to the question: "With the aid of what means, and who is going to do this?"

For example, the instructor and the commander prepare a pilot to carry out a flight assignment in a purely professional regard. But who is responsible for or, more precisely, who actually carries out psychophysiological preparation of the pilot? At the present time this is assumed by those same commanders and instructors, and sometimes flight surgeons. But are they prepared to do this in a skilled and qualified manner? After all, the human psychology is many times more complex than any musical instrument, and clumsy handling will immediately produce a sour note and a reverse reaction.

In Moscow, for example, psychological stress-relieving rooms have been set up at bus terminals for the drivers, and regular staff psychologists are being hired at industrial plants. We see this not only as concern for people but also a concerned attitude toward people's psychological and emotional reserves. This approach makes it possible to maintain a normal psychological status in the process of one's work and, if necessary, to carry out rehabilitative measures in regard to persons who display deviations in their functional state at the end of a work shift. When will similar concern be shown for military pilots? After all, their job is many times more difficult than that of a bus driver!

In a group of veteran combat pilots the motive to improve skills is gradually replaced by the motive to maintain and retain skills and abilities. Needs to advance in one's career, to improve one's position in society, and to pass on amassed experience and know-how to the younger pilots are manifested. It is therefore not surprising that veteran pilots react particularly strongly to failure to observe the principles of social justice in promotions, etc. Among factors which negatively affect their professional motivation, in questionnaires they most frequently indicate unwarranted delay in promotion, favoritism and protection, lack of moral and ethical scruples on the part of superiors, etc.

Heavy psychological and emotional stresses usually begin to make their presence known during this period of one's career. And although this does not always result in

illness, signs of excessive fatigue begin to show up in pilots This forces them to pay more attention to their own psychological and emotional state and physical condition. For this reason it is very important to switch pilots' attention from looking for pre-illness signs to prevention of possible ailments. These mandatorily include a healthy way of life, self-regulation of functional state, psychological reinforcement and self-relaxation....

Optimization of flying activity cannot be achieved by waving a magic wand. What is the answer? We feel that it lies in accelerated practical resolution of the problem of consideration of the human factor in military aviation and in establishing psychological support services. Effectiveness and reliability of flying labor can be increased only on the basis of comprehensive consideration of human psychophysiological characteristics and capabilities at all phases of aircraft design and development and when organizing flight activities. One-sided measures as a rule cause changes in people's economic, social, moral and ethical relations and interrelationships which bring down their effectiveness. As a result what at first glance are good intentions lead to negative consequences.

The cost of pilot training is steadily rising. For this reason we should make a stronger effort than ever before to extend the length of a pilot's flying career. This task can be accomplished only by displaying genuine concern and attention toward the needs and aspirations of flight personnel and by providing the required living conditions, material conditions, and psychological support. The means for this will be found if the necessity is perceived and, most important, if there is the desire to face the problems of military aviators. In the final analysis this also constitutes the goal and substance of restructuring processes.

Assuring a Reliable Afterburning Turbofan Engine Start

90SV0004E Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 4, Apr 90 (signed to press 28 Feb 90) pp 12-13

[Article, published under the heading "Mastering Modern Aircraft," by Lt Cols A. Khvostov and S. Khodatskiy, candidates of technical sciences, and Maj V. Maslov, air regiment aircraft maintenance unit chief: "Reliability of Engine Start"; concluding part of two-part article; part one appeared in the March 1990 issue of AVIATSIYA I KOSMONAVTIKA]

[Text] **In the first part of the article "Reliability of Engine Start," flight personnel, engineers and technicians were provided with general information on the physical nature of the processes which take place during afterburning two-spool turbofan engine (TRDDF) start, which have been inadequately discussed in the specialized literature. In the materials which follow, the authors, responding to the requests of operating, servicing and maintenance personnel, have devoted principal attention to mastering practical techniques of ensuring a TRDDF engine start in various conditions.**

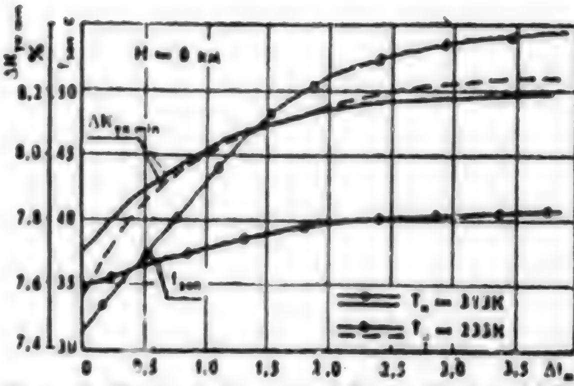


Figure 5. Change in Duration of Engine Start and Minimum TRDDF Compressor Gas-Dynamic Stability Factor With Time, to Which a Varying Thermal State of Engine Components Corresponds.

* * *

Practical experience with modern engines indicates that up to the present time engine starting has presented certain difficulties, both at low and high ambient temperatures, difficulties caused by "cold" hangup of turbine spooling and excessive exhaust gas temperature. One of the reasons for this is non-steady-state heat exchange in the engine.

Engine components are subjected to considerable thermal stress during engine start. Substantial and rapidly-changing temperature drops between gas stream and structural components lead to the occurrence of massive heat flow. The quantity of energy withdrawn from the exhaust gas for engine heating during the process of engine start varies, depending on the ambient air temperature and the engine's thermal state prior to engine start. Figure 5 shows the effect of time interval Delta-t, from the moment of shutdown of an engine (turbine wheel halt) which had been running on idle for 2 minutes, to commencement of a repeat start attempt, on engine start time ($t_{зап}$) and minimum compressor gas-dynamic stability factor (Delta$K_{yk\ min}$). It is apparent that the duration of a repeat engine start attempt is reduced (to 45 percent when T_H=233 K and Delta-t=0), but one observes an increase in exhaust gas temperature and decrease in Delta$K_{yk\ min}$ (by a factor of 1.1 when T_H=233K and Delta-t=0) due to decrease in accumulation in engine components of heat released during fuel combustion. A downward adjustment of fuel flow, in this case in order to ensure the required level of Delta$K_{yk\ min}$, leads either to an increase in $t_{зап}$ or to "cold" hangup of turbine spooling.

A quantitative estimate of thermal phenomena in the process of a TRDDF engine start was obtained in examining heat and energy balances. For example, the following balance is maintained at any moment in time: $Q_k+Q_r=Q_{1\ вых}+Q_q+Q_H$, where Q_k is the heat flow carried by the airstream into the combustion burner; Q_r is the heat flow caused by fuel combustion; $Q_{1\ вых}$ is the heat flow carried out of the engine by the exhaust gases; Q_q is the heat flow equivalent to the net power expended

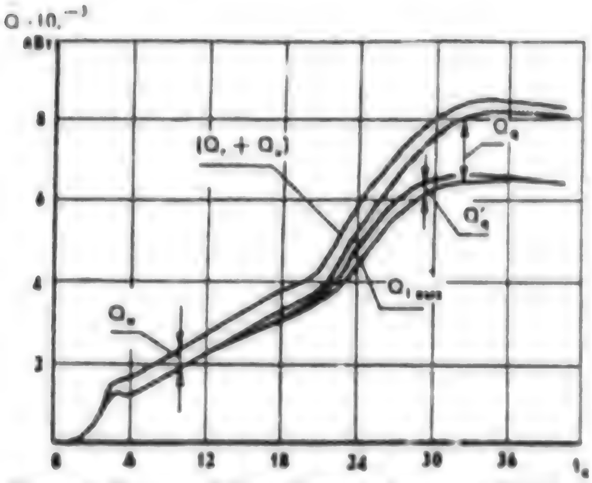


Figure 6. Balance of Heat Flows in Process of TRDDF Engine Start.

on turning and spooling up the turbine wheels; Q_H is the sum total heat flow heating engine turbine components.

Figure 6 shows a TRDDF engine start process balance (at standard atmospheric conditions) computed on the basis of a model; Q^*_q is the heat flow equivalent to net power expended only on spooling up the turbine wheels.

Heat flows lost to heating engine components at various phases of engine start (Q_H—Figure 6) comprise 5-25 percent of sum total flows occurring during fuel combustion and carried by the airstream into the combustion burner (Q_k+Q_r.

Analysis of a diagram of the energy balance of fuel carried into the combustion burner during the 30th second of a TRDDF engine start cycle indicated (Figure 7) that up to 75 percent of the energy of the fuel entering the engine combustion burner at this moment is expended in losses in the form of heat dissipated into metal and exhaust gas energy.

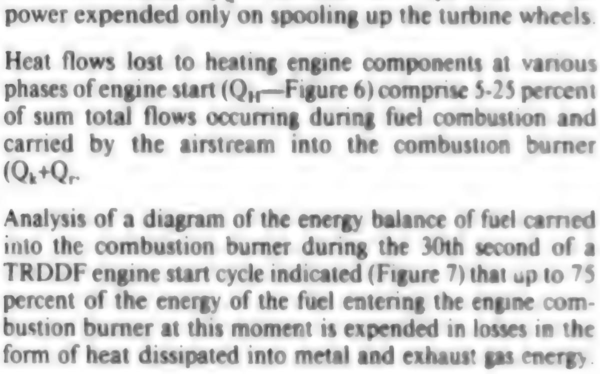


Figure 7. Diagram of Fuel Energy Balance During 30th Second of TRDDF Engine Start.

Key: 1. Turning TRDDF turbine wheels 2. Turbine wheel dynamics 3. Steady-state turbine wheel rotation 4. Heating of engine components 5. Losses 6. Exit from TRDDF inner duct

Fuel useful energy expended on turning and spooling up the turbine wheels comprises only 24 percent.

Thus calculations confirm that change in the startup properties of new-generation aircraft engines is taking place under the influence of non-steady-state heat exchange between the gas stream and engine structural components. This fact must be considered in organizing aircraft operation and maintenance.

TRDDF engine start at various ambient air temperatures is accompanied by various indices of air flow, pressures and temperatures as air passes through the hot section, and by change in rate of fuel flow, starter output, and other parameters. At the same time deviation of actual from rated starter output aggravates the negative effect of adverse atmospheric conditions—starter system parameters cease to be optimal and fail to ensure minimal duration of engine start.

An analysis of the heat exchange processes taking place in an engine's hot section indicates that in some cases (engine start at low ambient air temperatures or a second engine start attempt at temperatures above freezing) the heat flows expended on heating up engine components may prove to be so substantial that optimal engine parameters, characterizing engine start reliability and startup process duration, are not guaranteed. For example, at an ambient air temperature of +30° Celsius and higher, approximately 35 percent of repeat engine start attempts are accompanied by excessive exhaust gas temperature, which makes it necessary to terminate the engine start attempt and leads either to departure delay or to the aircraft remaining on the ground.

Figures 8 and 9 show the nature of change in gas temperature, starter power, rate of fuel consumption, and compressor gas-dynamic stability factor in the process of engine start at various ambient air temperatures. An analysis of the diagrams indicates that when ambient air temperature drops, the automatic starter control unit increases fuel flow (to n_k=0.35), and exhaust gas temperature decreases during the entire engine start phase. The minimum gas-dynamic compressor stability factor value remains constant at various T_H due to change in the rate of fuel flow, due to operation of the automatic acceleration control (when n_k is greater than 0.4)—see Figure 9.

In spite of an increase in starter output with a decrease in T_H (Figure 8), the specified duration of the engine start process is not ensured, and "cold" engine spooling hangup occurs at lower T_H. In this case worsening of engine start properties is manifested not only in less-complete fuel combustion and worsening of the quality of fuel atomization due to increased viscosity, but also in the occurrence of non-steady-state heat exchange between the hot gas and engine structural components.

Further examination of the curves in figures 8 and 9 (with a decrease in T_H there is a decrease in T^*_r, Delta$K_{yk\ min}$ remains unchanged with a decrease in G_t caused by the automatic acceleration control, and increase in t_{3an}) indicates that a decrease in t_{3an} and

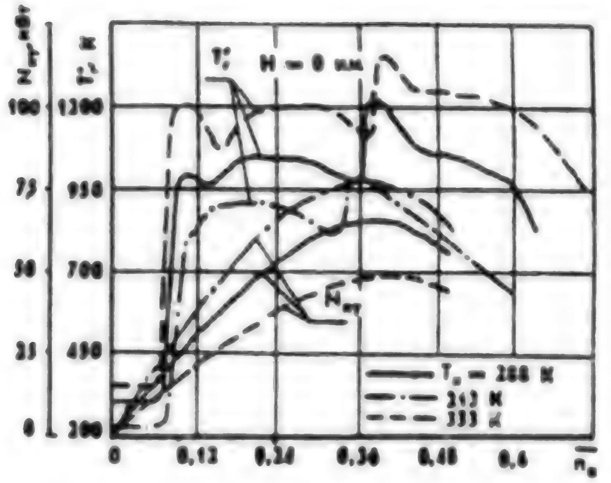


Figure 8. Change in TRDDF Exhaust Gas Temperature and Starter Output With Change in Ambient Temperature.

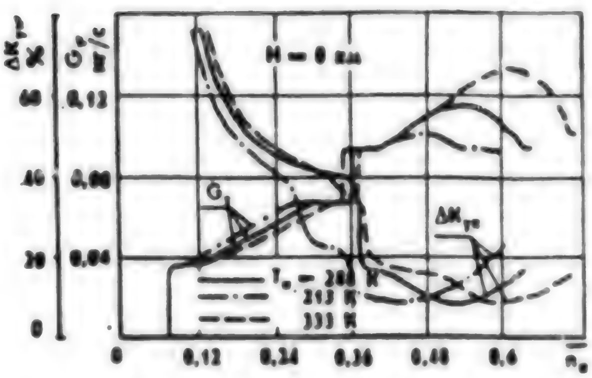


Figure 9. Nature of Change in Rate of Fuel Flow and Compressor Gas-Dynamic Stability Factor During TRDDF Engine Start With Change in Ambient Air Temperature.

elimination of the possibility of "cold" hangup of turbine spooling can be achieved by reducing losses to engine component heating of heat released during fuel combustion during the engine start process. In this case it is advisable to preheat the engine before starting, although this requires additional time expenditure on readying the aircraft due to inconveniences in arranging for and conducting preheating (in many instances, with relatively short time intervals between engine starts, in order to avoid the need to preheat an engine prior to start, it is necessary to place covers on the jet intake and exhaust.

Analysis of change in TRDDF parameters in the process of engine start with protracted T_H indicates that engine start may be terminated as a consequence of excessive exhaust gas temperature. Acceptable engine start properties in these cases, as well as in the case of repeat engine starts, can be ensured by retarding fuel feed during the initial phase of engine start by placing (some time after commencing the start procedure or when the turbine spools up to a certain rpm) the throttle in the idle position. When fuel feed is retarded, engine cooling occurs during the initial phase of engine start due to the running of air ("cold cranking") through from the intake.

If limits are exceeded during engine start, as well as when the engine fails to start, one must determine the reason and adjust the compressor control system units (automatic starter control and automatic acceleration control). It is advisable to perform these procedures on a preheated engine, which eliminates the possibility of excessive exhaust gas temperature during subsequent engine operation. When making control adjustments one should bear in mind that duration of the start process and time to throttling back to idle, specified by the operating manual, may differ by 10 to 15 seconds. In some cases ignorance of this point causes unnecessary overriding of the automatic engine start process. In addition, adjusting the automatic starter control changes the exhaust gas temperature to a greater degree, while adjustment of the automatic acceleration control determines the available compressor gas-dynamic stability factor.

Since in the case of repeat engine starts and engine starts in conditions of high ambient temperatures, worsening of engine start properties is connected both with decrease in starter output and increase in exhaust gas temperature, it is essential that one remember that possibilities of reducing fuel flow in this case can be limited not only by the compressor control system extreme adjustment positions but also by high-output operation of this system's components.

TRDDF engine start with a change in operating field elevation involves certain specific features. At high-elevation airfields, for example, the adverse effect of drop in barometric pressure leads to an increase in exhaust gas temperature and decrease in compressor gas-dynamic stability factor and starter output. Figures 10 and 11 show the nature of change in these parameters in the process of engine start at airfield elevations of H=0.1 and 2 km with change in ambient temperature and barometric pressure in conformity with international standard atmosphere.

It is clearly apparent that even changes in fuel flow effected with the compressor control system, with a change in airfield elevation, fail to eliminate an increase in T^*, and a decrease in Delta$K_{yk\ min}$, while with a further increase in elevation (above 3,500 meters), engine gas-dynamic parameters approach maximum values.

The adverse effect of pressure drop is neutralized in the course of engine operation and maintenance by an appropriate automatic starter control and automatic acceleration control adjustment to reduce fuel flow. Engine start time increases in this case, however.

We should note that the specific atmospheric conditions of high-elevation fields (the presence of wind, for example) lead to considerable air turbulence in the jet intake and tailpipe. In this case the engine start process is accomplished with a nonstandard air-to-fuel ratio.

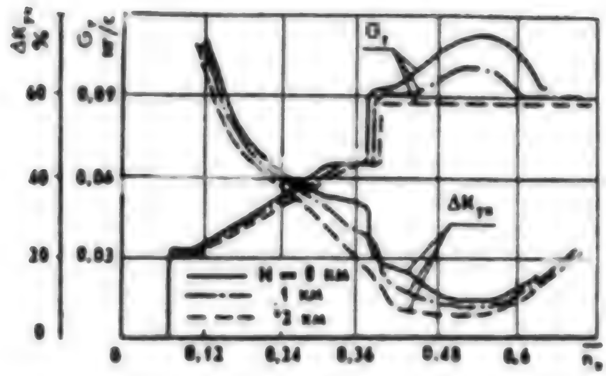


Figure 10. Nature of Change in Fuel Flow and Compressor Gas-Dynamic Stability Factor During TRDDF Engine Start With Change in Airfield Elevation.

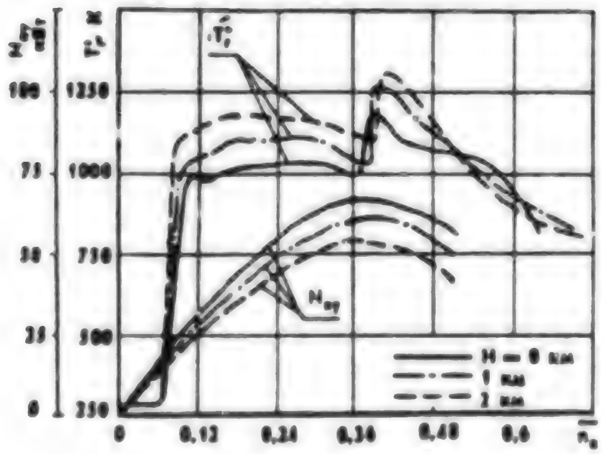


Figure 11. Change in TRDDF Exhaust Gas Temperature and Starter Output With Change in Airfield Elevation.

which causes elevated exhaust gas temperature and reduced compressor gas-dynamic stability factor. In these conditions it is not recommended that adjustments be made to alter rate of fuel flow during engine start, since adjustment of the compressor control system after this could be close to the limit, and in other operating conditions will fail to ensure the required reliability.

Study and utilization of the above will in our opinion enable flight personnel, engineers and technicians more knowledgeably to perform manual-prescribed procedures, which will ensure knowledgeable, reliable operation and maintenance of modern aircraft.

Training Pilots to Respond to In-Flight Emergencies

90SV0004F Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 4, Apr 90 (signed to press 28 Feb 90) pp 20-21, 29

[Article, published under the heading "Flight Safety: Experience, Analysis, Problems," by Military Pilot 1st Class Lt Col Yu. Kryukov and Lt Col S. Maslyuk, psychologist: "Preparedness for the Unexpected"]

[Text] **Military Pilot 1st Class Col Yu. Kryukov and psychologist Lt Col S. Maslyuk make a psychological analysis of training and preparation of flight personnel to respond in abnormal or emergency situations.**

There is a strong, traditional way of thinking when one examines the problem of a pilot's professional reliability: the better he is trained and prepared to do his job, the more reliably he will handle an in-flight problem or emergency. This is true, but even high proficiency-rated pilots sometimes perform in a less than brilliant fashion in a difficult situation.

* * *

"An outstanding pilot is he who, using excellent thinking, avoids situations which require outstanding skill and ability." One is hard put to argue with this statement, which is accepted by flight safety services in the West. But nevertheless a military pilot as described above at the present time remains merely an ideal. In actual practice many times it is not possible to avoid in-flight situations which require outstanding skill and ability. For this reason the problem of forming such skill in each and every pilot, regardless of his level of training and proficiency, is one of the key problems in flight safety theory and practice.

An analysis of military aviation mishaps in recent years indicates that more than 60 percent of air mishaps have occurred through the fault of personnel, including flight personnel. Consequently, if one adopts even a not entirely rigorous objectivity of investigation of air mishaps as an essential condition, nevertheless there is an inescapable conclusion that the existing system of training and testing the preparedness of a pilot (aircrew) to respond to abnormal or emergency situations (OS) leaves something to be desired.

Automation of air traffic and aircraft control, which began back in the 1960s, has not yet solved the problem of reliability of functioning of the "pilot-aircraft" system, since from the very outset it was focused on broadening the area of employment of aircraft and on extending aircraft capabilities. The complexity of the pilot's job is continuing to increase, and the pilot's emotional and psychological assets in reserve for possible malfunction and failure of automated systems are decreasing. For this reason often even a relatively simple, objectively non-dangerous complication during flight is subjectively perceived by the pilot (flight crew) as an emergency situation.

As we know, one and the same in-flight emergency, such as engine failure, can cause quite different emotional and mental reactions, even under identical flight conditions. And this applies not only to different pilots (crews) but also to one and the same pilot (crew) at different times, depending on the degree of his mental preparedness. There can occur in-flight abnormal situations or emergencies which are described in the manual as well as situations which are not covered in the manual and responses to which have not been practiced in advance. Of course training to respond to in-flight problems should form and shape a pilot's (crew's) ability to respond in a manner adequate both to a likely in-flight situation and an unexpected emergency situation.

Likely in-flight situations (in conformity with the sequence of response actions stated in the aircraft operating manual) are practiced and rehearsed during training sessions on flight simulators and in aircraft cockpits. It is considered that for each such situation, and they may number 70 or more, depending on the type of aircraft, the pilot (crew) must develop, regardless of his proficiency rating, solid automatic-response habits (skills) and continuously maintain them at a level ensuring flight safety. And when there occurs an in-flight situation for which crew response has been practiced and rehearsed, a certain response signal "switches on" the required pattern of response actions, and the pilot (crew) counters the situation. If this does not happen, however, the only person responsible is the pilot himself or the superior who prepared him for the flight. This approach to examination of a pilot's activities pertaining to the principle of "stimulus-reaction" is not new. Nor can it fully solve the problem of adequate pilot response to the occurrence and development of an in-flight abnormal situation, even one for which he has practiced.

An actually-occurring in-flight abnormal situation or emergency, mentally reflected by the pilot, goes through several phases in its development.

The first phase is decision-making. Any abnormal or emergency situation, even one characterized by quite specific information (sound, for example), requires that the pilot make a new decision after he has analyzed or at least verified the correctness of the warning information. Therefore at the first phase, from the moment the abnormal-situation warning is received to the first action taken by the pilot (crew) in response, the situation is subjectively an emergency, regardless of whether or not it is described in the operating manual, and exerts a psychological and emotional effect on him. The higher the degree of certainty of warning information and the greater the pilot's emotional-volitional stability, the shorter the first phase will be. It is the phase of maximum vulnerability and takes up two thirds of total available time for taking corrective action to the problem situation.

The second phase involves decision execution. In conformity with the specific conditions of the flight, the pilot (crew) executes a program of actions influenced by a new factor—the purpose of the flight. This is done independently of whether or not the given situation is described in the aircraft operating manual.

An unusual or unforeseen emergency situation in the second phase is characterized by considerably greater stress and uncertainty and requires a high degree of emotional-volitional stability and quick thinking. Categorizing possible in-flight situations and forming automatic corrective responses during ground training cannot fully solve the problem of preparing a pilot (crew) to respond in a difficult situation (both minor and serious), for in the course of preflight preparation only 17 percent of allocated time is expended on practicing and checking skills required for response to an in-flight problem. The amount of information exceeds by severalfold the volume of information utilized in carrying out flight assignments.

It has been demonstrated that in the course of a single readiness check it is practically impossible to determine even a pilot's general readiness (that is, knowledge of sequence of response actions as stated in the operating manual) for each type of in-flight situation due to the great number of different situations. And in the absence of acceptable criteria of situation response readiness for each crew member, this check becomes nothing but a test of the men's memory.

We conducted a study in which more than 400 aircraft commanders at various levels of command took part: rank-and-file pilots, a division commander, flight-school commanders, instructor personnel, test pilots, and flight safety service chiefs. None had less than a second-class proficiency rating, and all had been flying at least four years and had experienced the most varied in-flight problem situations.

Prior to departure, more than 80 percent of flight personnel are confident that the flight will conclude safely and do not figure on any problems aloft. And although they do not totally dismiss such a possibility, confidence in their own ability and in the reliability of the aircraft predominates, constituting an essential condition for psychological readiness to fly. In our opinion the rest of the pilots either subjectively incorrectly assess their own state, or else their personal qualities, at least temporarily, for whatever reason, are not up to the demands of the job. For a pilot (crew) in this category, each flight (regardless of its complexity) becomes an "accomplishment" and is attended by continuous heightened stress, reducing crew reliability virtually to zero.

One should bear in mind here that, alongside a positive effect on a pilot's emotional and psychological makeup by his confidence in the safe conclusion of a mission, one must consider that such confidence (not consciously controlled and reinforced by a protracted period of flying without mishap) fosters loss of professional caution. There is an increase in the psychological and emotional effect of the element of surprise, which is mandatorily present at the beginning of any abnormal or emergency

situation. For this reason an objectively identical situation is perceived variously by a pilot and can sometimes end in the most unexpected manner.

The above is graphically confirmed by an analysis of in-flight emergencies and abnormal situations conducted at a certain flight school. Flying in daylight and in VFR conditions, one of the engines failed on a helicopter being flown by a first-year cadet who had logged a total of 32 hours of flying time. Responding knowledgeably and with composure, he landed at a site away from his home field. The same thing happened to a helicopter being flown by an instructor who had logged more than 2000 hours, as he was turning onto the crosswind leg. This was not a serious problem for an experienced pilot, and he could have continued on one engine. The crew's hasty and erroneous actions in response to the engine failure, however, aggravated the situation. As a result, the helicopter crashed.

Thus a high level of job proficiency and comparatively favorable objective conditions in which the situation occurred suggested a safe outcome. But this was not to be, as a result of lack of the essential degree of psychological and professional preparedness. A subsequent accident inquiry indicated that an indirect reason for the instructor pilot's poor psychological preparedness was the fact that in the last six years he had not experienced even the slightest in-flight problem. Confidence gradually developed into excessive self-assurance, which led to diminished demandingness on himself. His sense of professional caution became dulled. As a result this experienced pilot lost the ability adequately to respond to an entirely-correctable in-flight problem situation. He perceived it as critical, that is, extremely complex, difficult and dangerous, evoking in him a feeling of helplessness, a feeling that the situation was hopeless, and even an inability to take any corrective action.

A directly opposite picture forms in the example with the pilot cadet. In this instance the student pilot's lack of professional experience was compensated for by the presence of the necessary personal qualities as well as the extreme composure on the part of the entire crew (the cadet navigator and the crew chief). Daily training drills (practice sessions) also had a favorable effect. All this enabled the crew promptly and realistically to grasp the situation, to reach an acceptable decision, and successfully to implement it.

A comparison of these two examples suggests the conclusion that excellent professional flying skills in normal flight conditions do not constitute a sufficient condition for correct response actions by a pilot (crew) in emergency situations. It is essentially prior to each flight to make the pilot (crew) psychologically prepared to encounter problems.

More than 50 percent of flight personnel who took part in the survey made substantial mistakes in stating the number of in-flight problem situations described in the operating manual for the type of aircraft they were flying. The lack of requisite classification of in-flight problems in the operating manual, due to the authors' endeavor to stress the importance of each such situation, compels the pilot subjectively to classify in-flight problem situations by their degree of danger.

Even those situations which are designated by flight personnel as the most dangerous are presented in the aircraft operating manual in the form of a list of signs or symptoms of malfunction and a fairly extensive (from 20 to 120 or more) sequence of response actions. Nor is the sequence of response actions substantiated. There is either no logical linkage between actions, or it is inadequately explained. And each situation involves large quantities of numerical information (as many as 70 different parameters), making memorization difficult.

Of those surveyed, more than 75 percent of pilots with from 4 to 10 years of flying experience stated that even in a calm ground environment they would be unable precisely, as presented in the operating manual, to state the sequence of response actions in each problem situation (without using "auxiliary" materials: written memoranda, notebooks, standard patterns, etc). Only 15 percent of instructor pilots, and all test pilots, were sure of their knowledge and, when tested, made few mistakes. As a rule the knowledge of pilots with from 4 to 8 years of flight experience proved to be fuller and more detailed. At the same time flight personnel with 8 or more years in the air do not consider such a degree of detailing of their knowledge essential, and they are firmly convinced of their ability to respond adequately to emergency situations which may arise. A comparative analysis of the manner and procedure of reaching a decision by young (less than 4 years flight experience) and veteran pilots in actual in-flight problem situations, as well as in testing their skills on the ground and in the air, suggests the conclusion that flight personnel form (at a certain stage of flight experience) a specialized algorithm of mental response actions involved in assessing an in-flight problem, reaching a decision, and verifying its execution.

A pilot who has formed such an algorithm can respond to an in-flight emergency in an unconventional manner, interpreting the practiced pattern in conformity with specific conditions, arriving at an optimal solution.

Not only veteran pilots but novice pilots as well, however, including student pilots, encounter in-flight emergencies. For this reason training a pilot (crew) to respond to an in-flight situation should form the requisite degree of emotional-volitional stability: knowledge, skills and abilities; the capability of effective intellectual response during the decision-making process, regardless of experience and length of service in flight duty.

The proposed method makes it possible to form (in the absence of concrete situational experience) a rough basis for response actions in emergency situations, substantially to develop the capability of rapid, efficient information evaluation, and properly to conduct practice

sessions and to test preparedness. It is grounded on the points and principles of psychological "theory of orderly forming of mental actions" and consists of two parts.

The first part comprises a specific methods system, which contains the following integral elements: a system of forming in flight personnel positive motivation for the process of acquiring knowledge and skills in responding to emergencies, and instructional aids which help develop the requisite knowledge, skills and abilities in flight personnel: training progression checklists, and sequences of general response procedures. These instructional aids present a description of the sequence of mental and control actions by the pilot (crew) in analyzing information, reaching and executing a decision in emergency situations; a set of problems, each of which is based on a specific emergency situation, but the volume of information is varied, and there is no direct addition of scenario instructions; an overall plan of action, which consists in integrating training progression checklists and training problems and forming a specific algorithm of response actions.

The second part of this method involves direct instruction in the aircraft cockpit, learning corrective actions to take in various emergency situations. The response actions being formed should go through the following stages: motivation in the process of practicing response actions; material (aircraft, weapons) or materialized (diagrams, drawings, graphs, etc) action; verbal action (oral or written) as a means of assimilation and testing; mental action as the end result of working out a problem, when the trainee can perform actions with the requisite quality.

Movement of actions from phase to phase is not linear but parallel. The relative share of each phase depends on the system of action response to each specific situation or situation segment. Each phase has specific means of monitoring and testing.

This method is presently undergoing testing and approval in army aviation units flying Mi-24 helicopters. We should state that initial results of the experiment are encouraging. We believe that employment of a method based on "theory of orderly forming of mental actions" will help solve the problem of training a pilot (crew) and testing his preparedness to respond to in-flight emergencies.

Current Mir Space Station Crew

90SV0004G Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 4, Apr 90 (signed to press 28 Feb 90) p 27

[Article by V. Lyndin: "Sixth Host Crew"]

[Text] The Soyuz TM-9 spacecraft lifted off from Baykonur at 0916 hours Moscow time on 11 February 1990. It was carrying mission commander Pilot-Cosmonaut USSR Col Anatoliy Yakovlevich Solovyev and flight engineer Aleksandr Nikolayevich Balandin. They have been manning the Mir space station since 13 February, having relieved the crew of Aleksandr Viktorenko and Aleksandr Serebrov.

Our readers are familiar with the life and career of Anatoliy Solovyev. But the flight engineer is on his first mission in space. The biography of Aleksandr Balandin, just as that of the majority of newcomer cosmonauts, is fairly straightforward. He was born on 30 July 1953 in the town of Fryazino, Moscow Oblast, to the family of a military man. Upon graduating from secondary school, Aleksandr enrolled at the Moscow Higher Technical School imeni N. E. Bauman. He was later assigned to the Energiya Scientific-Production Association, which had been established at the initiative of S. P. Korolev. It was changed to its present name following Korolev's death.

Aleksandr feels that he was quite fortunate: he took part in designing the Buran space shuttle. He himself wanted very much to fly! He applied, and in 1978 he was accepted to the cosmonaut corps, assigned to the Buran team. In preparing to become a flight engineer, he was studying a new vehicle which had not yet left the drawing board. He went through the specialized flight training program prescribed for those involved in the Buran program, and he made 25 parachute jumps.

Two years ago Balandin commenced training for a mission to the Mir space station. Buran manned flights are still a thing of the future, and actual space experience cannot hurt. The first test pilots who are to flight-test the Buran have also received practical manned-mission experience. The first shuttle crews may be made up of these individuals. But prior to that time a Mir space station crew will go aboard the Buran, and this is scheduled for next year. During this current mission Solovyev and Balandin are going to receive and put into operation a technology module, which will also be used for docking the Buran. For this purpose it will contain, in addition to a standard docking assembly, a combination male-female docking assembly. The Buran will have a counterpart assembly. Incidentally, a new vehicle is being readied for this mission, not the one which has already flown and was subsequently exhibited at the Paris Air Show at Le Bourget. The Buran will be launched unmanned and will dock with the Mir space station via the technology module.

Thus Aleksandr Balandin is in no way betraying the Buran project by transferring to the Mir program, since these two space systems development programs are not mutually exclusive, but on the contrary have many points of contact, right down to docking in orbit. But this is a thing of the future. In the meantime....

"We shall continue the experiments," Balandin commented prior to launch, "begun by previous crews, and we shall also conduct totally new experiments. The equipment aboard the additional equipment module

provides capability to test a closed-cycle water utilization system aboard the space station, without which long space flights are impossible. But the main thing is the technology module. In this module we shall begin experimental-commercial production of high-grade semiconductor materials for the microelectronics industry. We shall also be performing interesting experiments in biotechnology. We hope to make a contribution toward solving our country's environmental problems."

Space flight is not an end in itself. The space program can and must serve man, must justify the money invested in the program.

"Flying into space," I recall a statement made by Anatoliy Solovyev, "is not of itself a result. It is simply a fact. What is needed is a material expression, work with a certain result. And if what we do results in movement forward, then one can say that this was not simply a flight, but a job performed."

New Student Pilot Training Method Proposed

90SV0004H Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 4, Apr 90 (signed to press 28 Feb 90) pp 30-33

[Article, published under the heading "At Air Force Schools," by Military Instructor Pilot 1st Class Col N. Litvinchuk, candidate of technical sciences, docent: "Efficiency Reserve in Action"; part one of two-part article]

[Text] Following publication of an article entitled "Efficiency Reserve in... Reserve?" (AVIATSIYA I KOSMONAVTIKA, No 6, 1988), which examined ways to improve cadet flight training methods, a number of questions arose with our readers, pertaining to the scientific basis of the proposed approach, its role and place.

It is now clear that it is impossible to bridge the gap between the capabilities of modern aircraft and training of flight personnel, to transition to training on the basis of new instruction curricula packed with complex flight maneuvers, using the current extensive-type methods, without additional material outlays. Increasing the effectiveness of instruction in theory and ground training, achieving closer linkage between this instruction and training in the air, as well as all-out activation of the human factor constitute the most effective solution.

Experimental instruction of pilot cadets on trainers and combat aircraft using this approach, which has been conducted over the course of the last two years at the Chernigov Higher Military Aviation School for Pilots has produced positive results, which enables us to continue the discussion on this subject.

Practical experience confirms the fact that if in-air instruction always begins with demonstration, in the final analysis the student pilot loses faith in ground training and in the need for knowledge of theory. On the other hand, having been well prepared on the ground, he asks the instructor pilot: "Let me do it myself, without demonstration." And as a rule he is successful. Henceforth it is not necessary to force such a student pilot to prepare for training flights if one continues to offer him independence. As a result he develops initiative and the ability to work without outside assistance both on the ground and in the air, which our flight school graduates are lacking.

The essence of pilot training can be represented in a simplified manner in the form of filling in a certain volume of space with knowledge, simple and complex flying skills and abilities, characterized by the magnitude of mistakes committed while flying (see Figure 1). This can be done both during training in the air and on the ground (see Figure 2). Many commanders are skeptical about such an assertion, however, although when a training flight is unsuccessful they punish the pilot precisely for poor preparation for that flight.

We should note that with present methods these types of instruction constitute two separate processes lacking any precise interlinkage. All instructor good intentions connected with learning theory are lost at the juncture between these processes, in spite of the appearance of modern theory and methodology of teaching modern theory.

Each of these has its advantages and drawbacks. For example, Figure 3a shows structure of training and instruction only on the ground (preflight training). A good foundation of knowledge and a certain level of skills and abilities can be formed here with comparatively modest material outlays. The harder and more persistently the student pilot works, the more up-to-date the methodological foundation and the training simulators, and the better prepared the instructor, the higher the level of attained skills and abilities.

Figure 3b shows a flight training structure using rote drill alone. Abilities and skills are formed well, but there is no foundation of knowledge. Even an experienced pilot is unable to discuss and explain in detail the technique of executing flight maneuvers if he was trained in this manner. These skills can be maintained and restored only by means of regular and supplementary training flights, which requires considerable material expenditures.

The conclusion suggests itself that these two types of training be combined, adopting their most valuable aspects (see Figure 3c). Combining should occur at a level ensuring that the student pilot can execute independently, without in-air demonstration by the instructor, to a mark of not less than satisfactory and without violating safety regulations, that flight maneuver for which he studied and prepared on the ground. The instructor acts as safety pilot in order to ensure flight safety, giving the student pilot the opportunity to learn on his own.

This level of ground training and preparation is not always sufficient for the student pilot to fly without

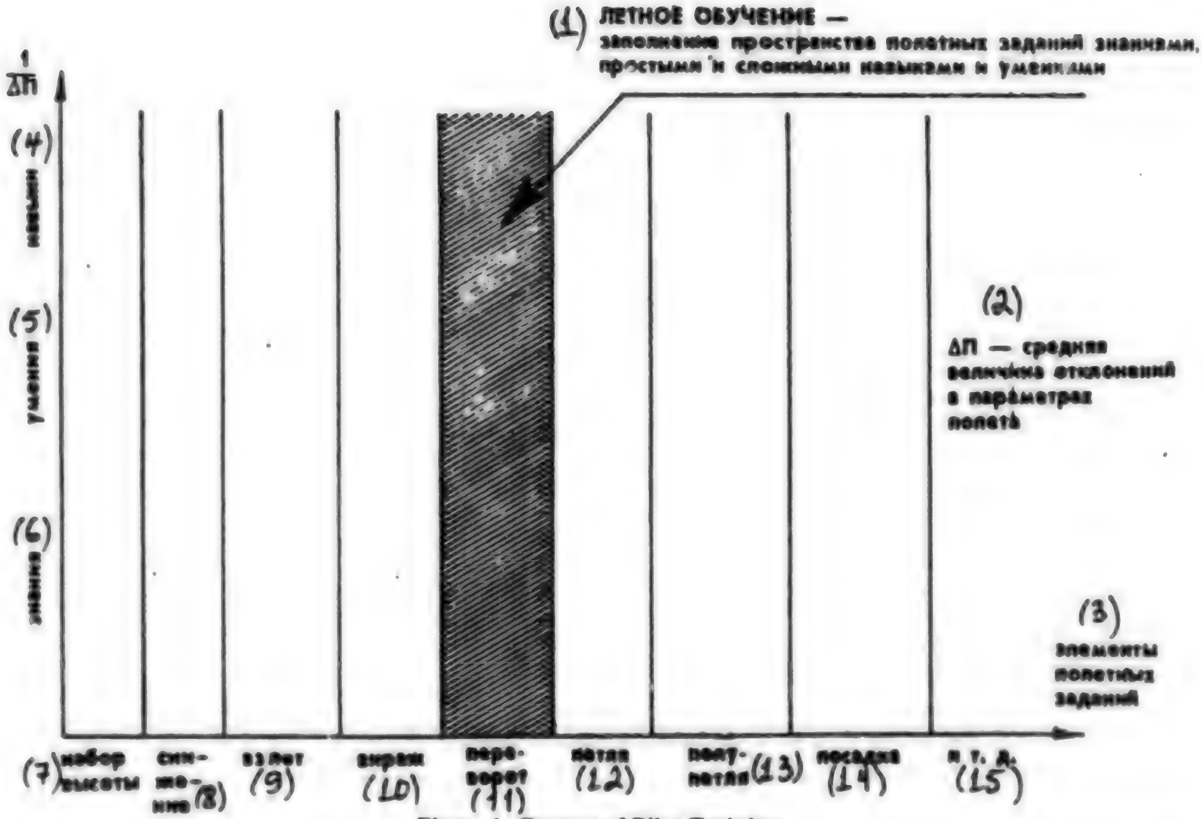


Figure 1. Content of Pilot Training.

Key: 1. Pilot training—filling in volume of space represented by training flight assignments with knowledge, simple and complex skills and abilities 2. Average magnitude of error in flight parameters 3. Flight maneuvers 4. Skills 5. Abilities 6. Knowledge 7. Climb 8. Descent 9. Takeoff 10. Banked turn 11. Half roll 12. Loop 13. Immelman 14. Landing 15. etc

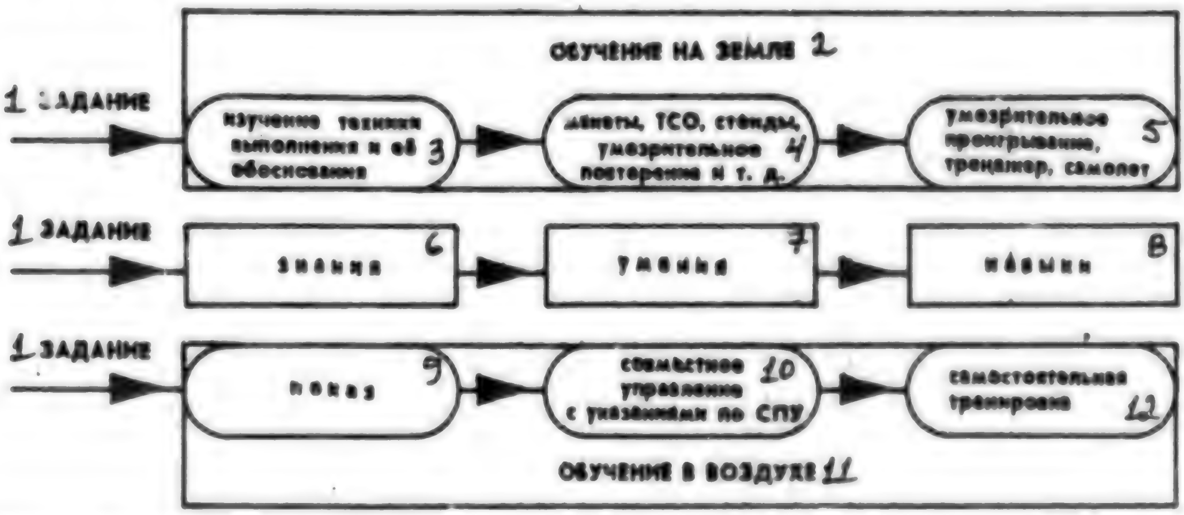


Figure 2. Simplified Diagram of Forming Flight Skills and Abilities During Training on the Ground and in the Air.

Key: 1. Assignment 2. Ground school 3. Study of execution technique and substantiation of technique 4. Models, technical training aids, training displays, repeated mental execution, etc 5. Mental execution, training simulator, aircraft 6. Knowledge 7. Abilities 8. Skills 9. Demonstration 10. Execution together with instructor, with instructions over interphone 11. Flight training 12. Practice without instructor assistance

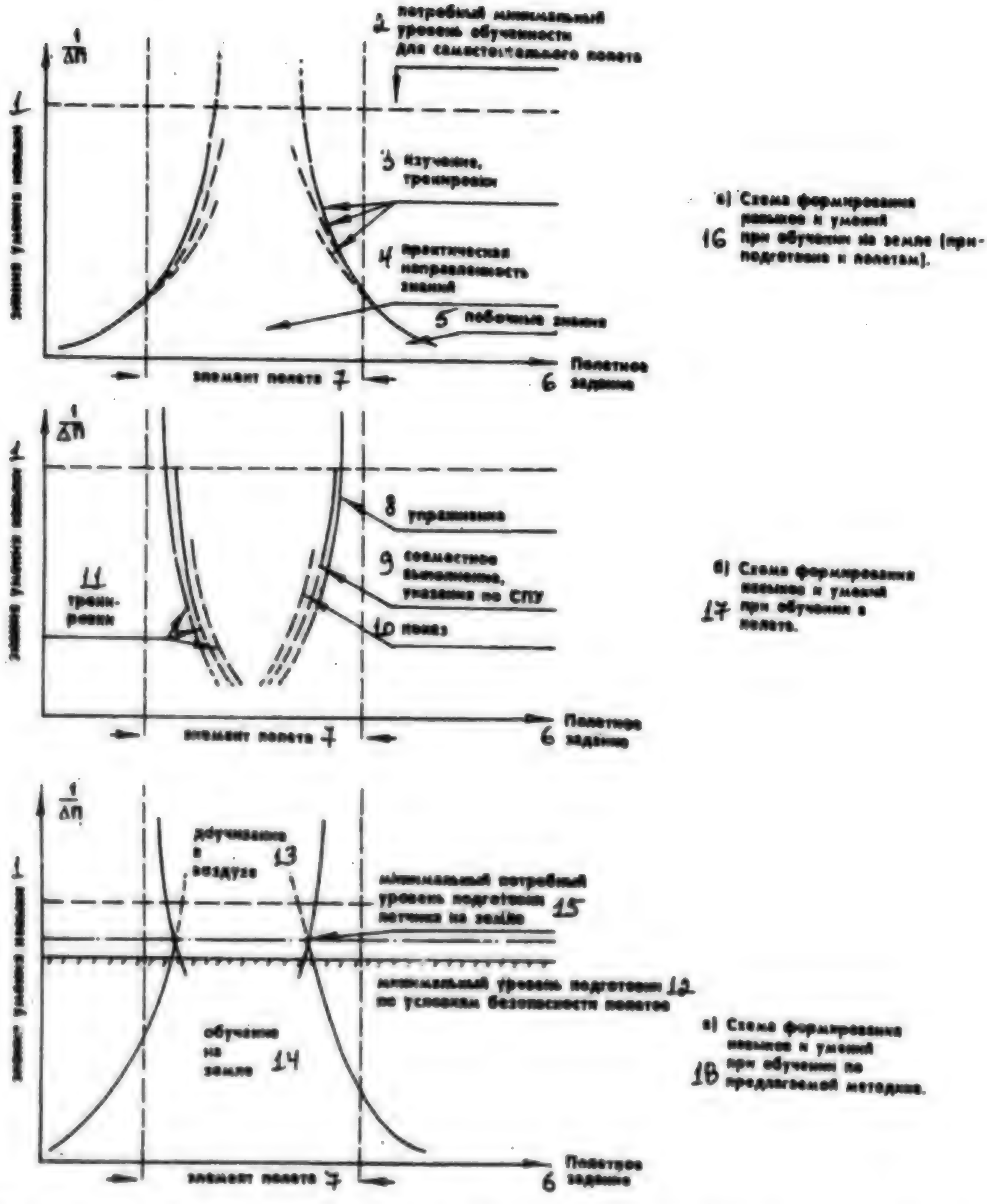


Figure 3. Process of Forming Knowledge, Flying Skills and Abilities During Ground School Instruction and Flight Training.

Key: 1. Knowledge, abilities, skills 2. Requisite minimum level of proficiency for solo flight 3. Study, practice drills 4. Practical directional thrust of knowledge 5. Collatoral knowledge 6. Flight assignment 7. Flight maneuver 8. Practice 9. Execution together with instructor, instructions over interphone 10. Demonstration 11. Practice drills 12. Minimum level of proficiency based on flight safety conditions 13. Additional learning in the air 14. Ground training 15. Minimum requisite level of pilot training on the ground 16. a) Diagram of Forming Skills and Abilities During ground Instruction (preflight training). 17. b) Diagram of Forming Skills and Abilities During Flight Training. 18. c) Diagram of Forming Skills and Abilities During Training According to the Proposed Method.

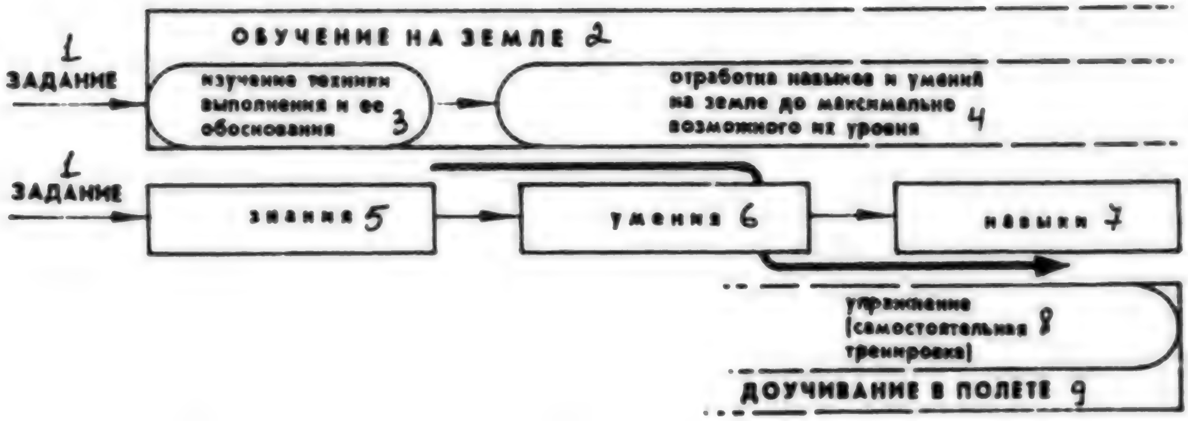


Figure 4. Diagram of Forming Flying Skills and Abilities With Training and Instruction Using the Proposed Method.

Key: 1. Assigned task 2. Ground training 3. Study of execution technique and technique substantiation 4. Mastering skills and abilities on the ground to a maximum possible level 5. Knowledge 6. Abilities 7. Skills 8. Practice (without instructor intervention) 9. Completing the learning process in the air

instructor intervention. One should not drop below this level, however, for otherwise the instructor is forced to take the controls, and the student pilot will be unable to assess his own proficiency.

Redundancy disappears with this approach. Instruction in the air does not "obscure" the result of ground training, as sometimes occurs at present with mandatory demonstration of flight maneuver execution, but becomes a continuation of ground training from the attained level, in an integral pilot training process (see Figure 4). Various ground training methods, including the "reference point method," begin to come into play here and reach a logical conclusion.

Figure 5 shows the differences in methods of flight training. Adhering to safety procedures, the instructor teaches the student pilot, maintaining flight parameters in the "quality envelope" during demonstration and when backing up the student pilot. Just prior to student soloing, they emerge from these rigid restrictions, working on mastering correction of errors.

In the proposed approach the training process commences with mastering correction of maximum allowable errors. As skills and ability are acquired, the quality of the flight performance proceeds into a "quality cone" until the required level of proficiency is reached. After this the student pilot is permitted to solo. This instruction and training procedure helps develop a specialist possessing greater reliability, while training flights specifically to master error-correction skills lose their significance.

The opposing nature of these methods is also due to enhancement of the role of preflight ground training and preparation in the overall pilot training process (see table). Another specific feature of the proposed method is the fact that even when an adequate level of proficiency is achieved after the student pilot has performed new flight maneuvers from two to four times without instructor intervention, he needs a demonstration by the instructor of ideal maneuver execution technique in order to be certain that his technique is correct.

Table

Established	Proposed
1. Demonstration of correct flying technique.	1. Practice session executing maneuver, without instructor intervention, for which student pilot has been preparing.
2. Instructor-assisted execution of flight maneuvers, with instructions via interphone.	2. When necessary: instructions over interphone, or instructor-assisted execution with instructions over interphone.
3. Practice session executing maneuvers without instructor assistance.	3. When absolutely necessary: demonstration of correct execution technique.
	4. Periodic, after every 2-4 executions by the student pilot, demonstration of ideal execution technique.

Instruction involving a reduced role by in-air demonstration is not an end in itself. Thiss is a means of forcing the student pilot to work efficiently on the basis of his own personal self-interest. The instructor suggests to him, as it were: "See for yourself what you are capable of, assess the results of your work on the ground, learn to work on your own, and I shall function as safety pilot." What we have here is a shift from the presently generally-accepted principle of "teach the student pilot to fly" to the principle of "provide the student pilot with the opportunity to learn to fly on his own."

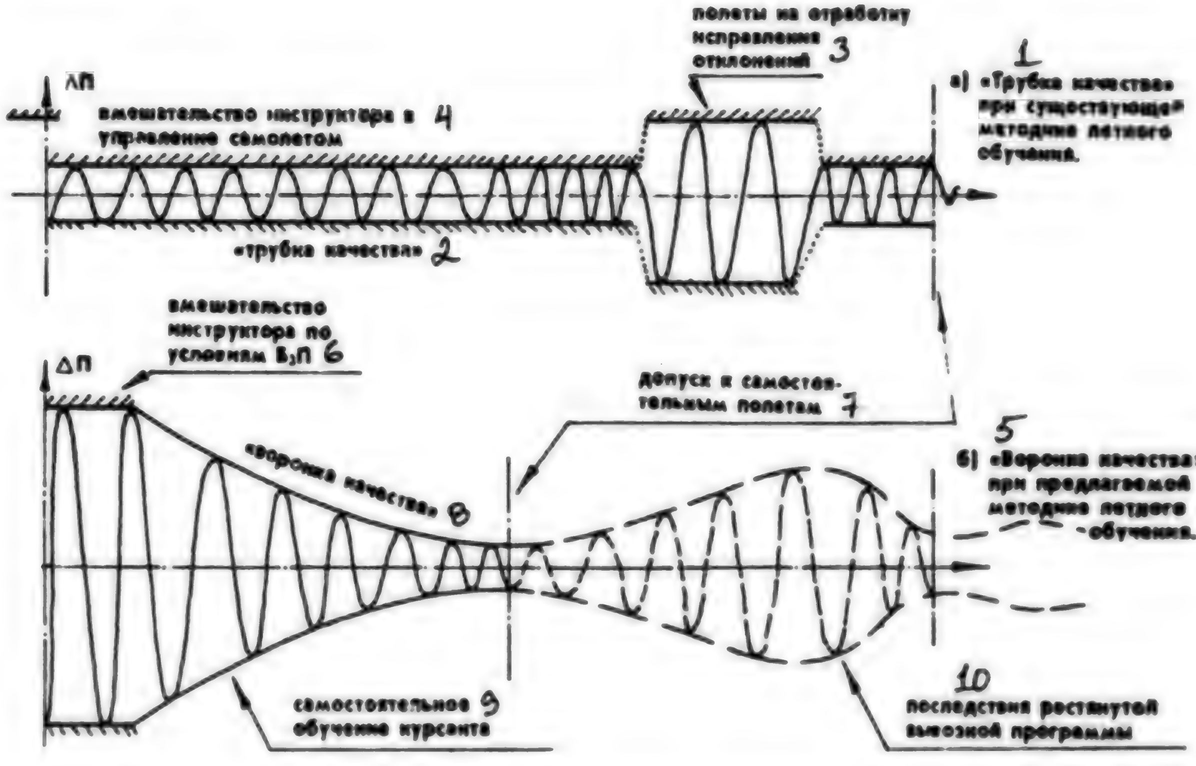


Figure 5. Essential Differences in Approaches to Dual-Instruction Flight Training.

Key: 1. a) "Quality envelope" with existing pilot training method 2. "Quality envelope" 3. Training flights to master correction of errors 4. Instructor intervention in taking over the controls 5. b) "Quality cone" with the proposed pilot training method 6. Instructor intervention based on flight safety conditions 7. Approval to fly solo 8. "Quality cone" 9. Student pilot works unassisted 10. Consequences of stretched-out dual instruction

In comparison with conversion-training flight personnel over to a new aircraft without a dual trainer, as well as training of test pilots and cosmonauts, the proposed approach has one substantial difference. It presumes the presence of an experienced instructor on board in addition to the student pilot, with the instructor acting as safety pilot. In actual practice many veteran instructors have to one degree or another conducted pilot training with employment of elements of this approach. Unfortunately the experience of such activity has not been synthesized and disseminated, since mere failure to adhere to the existing method was considered a violation of regulations and would be punished.

We shall cite some results of experimental instruction on a MiG-21.

In 1988 the third-year cadets of a certain air squadron trained using the proposed method, within the framework of the existing minimum dual-instruction program of 36 training flights. After they reached the level of solo flight (after 10-18 flights), quality of flying technique began to drop off (see Figure 6).

Regulations did not provide for flying solo at this moment. As a result it was necessary to complete the dual-instruction flight program in conditions of declining proficiency, a decline in flying proficiency from which some of the student pilots were unable to recover and were washed out of the program. This explains the pulsating configuration of the "quality cone" (Figure 5) and casts doubt on the current view on the reason for the decline in quality of flight performance after it has reached a peak level or following several solo flights involving the same training assignment. It was believed that the only contributing factor was the forming of an individual signature of flying technique in the student pilot after copying his instructor's technique. Flight training using the proposed method, aimed at developing individual flying skills, indicated that such declines in quality of flying technique are a logical phenomenon. They always occur if the main objective has been achieved but the pilot continues to perform flight maneuvers which have already been mastered, while he lacks incentive to improve his technique.

Also interesting is the fact that the cadets in the experimental group recorded three times fewer mishap-threatening incidents, and less dangerous incidents, than other cadets during solo flights.

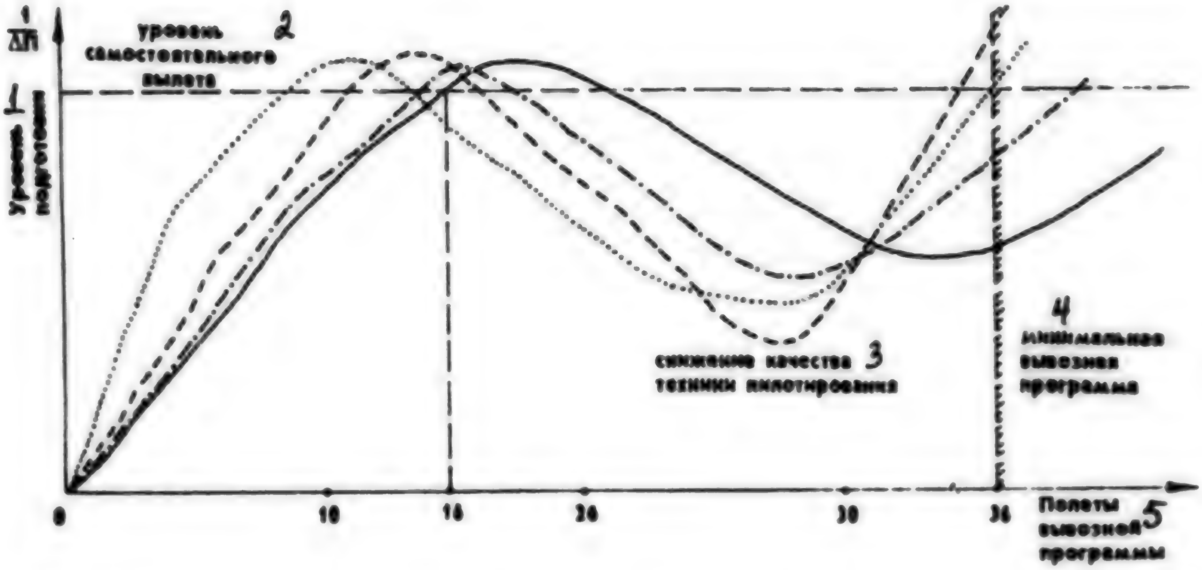


Figure 6. Change in Level of Flying Proficiency With an Extended Dual-Instruction Program.

Key: 1. Level of proficiency 2. Level of solo flight 3. Decline in quality of flying technique 4. Minimum dual-instruction program 5. Dual-instruction program flights

In the experimental pilot training in 1989, the above-noted deficiencies were for the most part taken into consideration in the new training program drawn up at the school, under the direction of Col V. Sobolev. The new program made it possible to allow student pilots to solo after reaching the requisite level of proficiency with a minimum dual-instruction program of 12 training flights. And the first of the student pilots met the standards, although many could have soloed even sooner. The higher command echelon decided to increase the dual-instruction program by an additional four hours just to be on the safe side.

Figure 7 [missing from source] contains the results of the experimental flight training in comparison with other years. Even in such adverse conditions where not all instructors were willing immediately to shift to the new flight training method, the average number of dual flights before soloing, without detriment to quality, decreased from 44 to 21. Direct savings totaled 800,000 rubles just for four air squadrons. If this money was put into housing construction, housing would no longer be an acute problem in the unit. **(To be concluded)**

New Aircraft Spare Parts Supply Management System Proposed

90SV0004I Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 4, Apr 90 (signed to press 28 Feb 90) pp 34-35

[Article, published under the heading "Putting the Recommendations of Science Into Practice," by Maj Gen Avn A. Batalov: "Strategy—Management by Levels"]

[Text] One of the most important factors determining the operational readiness of Air Force subunits is provision of spare parts. Unfortunately, in spite of substantial expenditures, aircraft time out of service due to lack of spare parts is not decreasing. This is due not only to high spare parts requirements but also to deficiencies in the logistic support system. The situation could continue to deteriorate in conditions of conversion and cuts in budget authorizations for procurement of spare parts, if profound organizational and technical measures are not implemented to improve the logistic support system. How can the situation be corrected?

As we know, the system of providing spare parts includes supply, industrial procurement, and depot-level maintenance entities. Practical experience has shown, however, that supply, a "circulatory system," as it were, constitutes the basis for the successful functioning of this system as a whole. Experience in logistical support, however, attests to the fact that the serious deficiencies existing within the system cannot be compensated for by a simple increase in deliveries of spare parts from industry and an increase in the volume of maintenance performed. And in our opinion it is primarily because at the present time the scheduled shipment of spare parts from central-echelon supply depots and supply depots of Air Force large strategic formations is being done on the basis of annual supply plans and schedules and has practically no linkage to the current state of stocks on hand at the maintenance-performing level. Annual "reordering" of spare parts is running 25-30 percent.

With such allocation-determined supply, the central-level supply depots and those of the large strategic

formations virtually constitute transit facilities (transshipment points). A large portion of the spare parts inventory accumulates at the lowest echelon of the supply system—the aviation technical units and aircraft-maintaining subunits. This leads to an unwarranted increase in quantity of spare parts and to an artificial shortage, since management entities lack reliable information on the status of supply stocks. Shipments of spare parts in response to pulling aircraft out of service are also delayed due to the lack of modern means of communication, operations management, means of locating spare parts, poor level of mechanization of supply depot facilities, and inadequate utilization of air transport.

As a result, for third-generation aircraft the ratio of the value of spare parts on hand at storage facilities to their average annual consumption (in value terms) runs 200-300 percent, it takes more than 72 hours on the average to fill unit aviation engineering service requisition requests, while it takes 10 days or more on the average to deliver spare parts requested by air units for aircraft pulled out of service. The percentage share of aircraft equipment repaired or overhauled at aircraft maintenance depots is only 10-15 percent in terms of meeting the requirements of air units. In view of the fact that the cost of depot repair or overhaul of equipment averages 25-30 percent of the cost of new equipment, meeting line-unit requirements primarily by supplying new equipment leads to considerable material expenditures.

What conclusion can be drawn from the above?

Not a very reassuring one. The existing system of supplying spare parts is operating at a poor organizational and technical level and leads to accumulation of large stocks on hand, to substantial costs, and to extended time off the line for unserviceable aircraft.

Analysis also revealed the principal shortcomings of the existing system of allocation-based supply: an absence of organizational and economic factors which restrict the accumulation of spare parts with unreliable verification of status of stocks on hand, the existence solely of annual supply plans and the lack of short-term supply plans/schedules, inadequate utilization of highly-mobile means of transportation, and inadequate level of development of depot-level repair of components and assemblies. To some degree all this can be explained by the fact that up to the present time logistic support entities have been tasked with reducing down time of aircraft in unserviceable condition regardless of expenditures. Under current conditions, however, proceeding from the national interest, priority attention should be given to an economic approach.

Aggregate average annual costs connected with operation of the system of spare parts supply and aircraft down time due to lack of spare parts can be used as a synthesized indicator of effectiveness of the spare parts supply system.

$$W=A_{st}+A_d+A_m+A_{dt},$$

where A_{st}—average annual cost of maintaining supply stocks; A_d—average annual cost of delivering spare parts; A_m—average annual cost of management and communications; A_{dt}—average annual cost connected with unserviceable-aircraft down time, that is, virtual "freezing" of funds spent on putting aircraft back into service.

We should note that, as we see it, an efficient system should ensure a minimal, or fairly close to minimal, value of indicator W. But in actual conditions, when selecting a given variation of supply system organizational arrangement, a decisive role can also be played by such additional indicators as number of personnel and number of allocated transport aircraft and trucks.

It has been established that the best technical and economic indices in supply management systems are achieved by management by levels. A standard level (norm) is established for each supply item list. Periodic (and continuous in certain instances) replenishment of stocks to the specified standard level is organized. Volume of supply deliveries is the difference between the standard level and actual stocks on hand at the moment the state of stocks on hand is checked.

A spare parts supply system, the operation of which is based on control of stocks on hand by levels, is called a standard-level system. In contrast to the existing allocation-type system, its basic operating principles are the following: determination of technically and economically validated standard levels of supply stocks at rear services supply depots, changeover from annual supply plans/schedules based on reports and requisition requests to short-term schedules based on standard levels, continuous or frequent check by management entities to determine the status of supply stocks, and extensive utilization of high-mobility transport assets for delivery, as well as conformity between industry procurement order schedule and the Air Force's actual spare parts requirements.

Practical utilization of level-by-level control of stocks on hand, which is an important advantage of this system, makes it possible not only to limit the accumulation of supply stocks but also to prevent the unwarranted occurrence of a short-supply situation. In each specific instance choosing a rational strategy of supply management consists in validating standard stocks on hand, periodicity of replenishment of supply stocks, and utilization of given means of transportation.

Analytical calculations and computer modeling of optimal variations of supply system organizational arrangement and functioning have shown that implementation of any optimal variation makes it possible in conditions of conversion, with a 15-20 percent reduction in volume of deliveries from industry, to reduce by a factor of 2-4 material expenditures connected with supplying spare parts, and to reduce by a factor of 2-2.5 the duration of serviceable aircraft down time due to lack of spare parts.

A line-unit experiment is currently underway. At the Air Force large strategic formation level, applying one of the possible variations of organizational arrangement of a system of level-by-level standard stocks. Preliminary results indicate that an essential and mandatory condition for successful functioning of a level-by-level standard-stocks supply management system is the establishment of specialized aviation technical support centers supported by central supply depots or aircraft maintenance depots, with these centers autonomously handling matters of supply, planning and scheduling supply procurement orders and maintenance.

The potentially anticipated effectiveness of adoption of modern methods of supply management in practical logistic support functions enables one to reach a validated conclusion that it is necessary to redistribute a portion of assets from the domain of spare parts manufacture to the domain of development of aviation-technical support [air force logistic support services].

As the line-unit experiment proceeded, it revealed fundamental difficulties in implementing this promising logistic support system. Difficulties are connected with allocation of highly-mobile transportation assets, particularly aircraft, as well as insufficiently-effective monitoring of supply stocks. While the first problem is being resolved in part by using available transportation assets proceeding in the right direction or toward the desired destination, the second problem can be properly resolved only with utilization of computers and integrated communications links.

In our opinion selection of a promising variation of system organizational arrangement and functioning should be made taking into account the availability of personnel and equipment, as well as the need for phase-by-phase transition to efficient logistic support services. At the same time one must bear in mind that the shortcomings of the existing manner of supplying spare parts are caused to a considerable degree by obsolete organizational principles, not by the lack of automated management systems. For this reason transition to an efficient supply system should be accomplished on the basis of existing assets and by gradual adoption of automated management.

Establishment of a modern spare parts supply system based on scientific management methods is a complex, integrated task. Successful accomplishment will require the joint efforts of Air Force central administrative authorities, scientific research organizations, military educational institutions, Air Force large strategic formations and units, and industrial enterprises. Only then will we be able, in conditions of conversion, substantially to reduce the cost of operating and maintaining aircraft, at the same time raising the level of aircraft serviceability and reliability.

Developments in Aviation Abroad

90SV0004J Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 4, Apr 90 (signed to press 28 Feb 90) p 39

[Briefs, published under the heading "Foreign Aviation Briefs"; based on materials appearing in foreign publications]

[Text]

The Computer—A Fighter's Second Pilot

In the opinion of specialists at McDonnell Douglas, in the 1990s U.S. combat aircraft pilots will be facing an adversary possessing superior numbers and with approximately the same level of equipment. They are therefore of the opinion that U.S. Air Force pilots should "be capable of shooting down 10 enemy aircraft for every friendly aircraft lost, with a force ratio of 4 to 1 in the adversary's favor." These people know what they are talking about, since they are involved in the ICAAS program (an integrated system of controls and avionics for ensuring air superiority). Working under contract with the U.S. Air Force, they are studying ways to reduce pilot workload and at the same time to increase pilot capability correctly to evaluate the situation.

The ICAAS system is based on such research projects as "Big Picture" (cockpit displays), "Agile Eye" (helmet-mounted display) and "Pilot's Associate" (second pilot), but it goes much further. It seeks not only to improve situation depiction by optimal display of data, but at the same time to provide a tactical situation assessment, and to present the pilot with possible alternative actions. The ICAAS system will analyze the "air-to-air" threat, "suggest" optimal attack-evasion maneuvers, and give the pilot, if requested, instructions pertaining to requisite flight profiles.

The basis for this kind of pilot support is utilization of parallel high-speed computers which "share" these tasks. McDonnell Douglas is using two Lear Astronics computers, with software written in the Ada language, for the ICAAS system.

Computer simulation testing, with the participation of USSR Air Force pilots, is to begin in mid-1990. McDonnell Douglas will use for this testing its flight simulator with spherical screen and "Big Picture" cockpit-display system. The instrument panel will contain components prescribed by the so-called "Cockpit-2000" concept. This will include, for example, a 25 x 25 cm color display, the "Agile Eye" helmet-mounted display, and the F-15E ARS-70 radar. Prior to commencement of

testing, the U.S. Air Force will make a decision on whether flight testing will also be performed beginning in 1991.

The people at McDonnell Douglas believe that the ICAAS system can be used both to increase the combat effectiveness of existing aircraft and is suited for installation on the Advanced Tactical Fighter (ATF). If it meets expectations, the developers estimate that it will be ready to enter operational service by 1995.

B-2 "Stealth" Bomber Engine

Finally more detailed information on the GE F118 engine, which powers the super-costly Northrop B-2 "Stealth" bomber, has appeared in open publications. It is a variation of the GE F110 and GE F101 engines, which power the F-16 and F-14 aircraft respectively. The F118 engine boasts greater maximum compressor flow and pressure ratio than the F110, and consequently produces greater thrust.

Supersonic Target Downed by Laser

For the first time a guided missile traveling at supersonic speed was brought down by a high-energy laser. In tests at White Sands (New Mexico) the U.S. Air Force used the MIRACL/SLBO system (a promising chemical laser operating in the mid-infrared region of the spectrum and the "Sea Light" beam control device). Its effective range was in conformity with a "realistic tactical scenario." As we know, tests against slow-speed targets were performed at the end of 1987.

Placement of Armament on LAH Helicopter

According to the client's requirements, the LAH light attack helicopter, which is being developed jointly by Great Britain, the Netherlands, Italy, and Spain, is not to carry externally-mounted armament. The Westland Company has proposed a unique design for accommodating third-generation Trigat antitank missiles, which operate on the "fire and forget" principle. The missiles will be carried inside fuselage-side fairings and will be fed downward and forward along the lower part of the fuselage onto a reloadable launcher on a swiveling turret under the nose.

As previously noted, there are differences of opinion among the participating countries regarding further development of the LAH program.

Dummy in Ejection Seat

The magazine JANE'S DEFENCE WEEKLY reports development of a specialized dynamic human mannequin for the development of experimental ejection systems prescribed within the ATF fighter development program which is being conducted in the United States (AVIATSIYA I KOSMONAVTIKA, No 12, 1989). The new aircraft is to be equipped with a CREST ejection system. It is believed that this system will provide safe pilot ejection throughout the entire speed envelope, up to 1,300 km/h, at low altitude, and when the aircraft is inverted.

The mannequin will also be used in conducting a set of tests in various flight configurations for the ATF. Specialists are of the view that all capabilities of the human organism will be exceeded during ejection at maximum speeds and at low level; in addition (and this was one argument in favor of using a "pilot analog" at this stage), multiple tests will be required in the course of developing the design and construction of a future ejection seat. The mannequin's arms and legs are capable of simulating pilot movement in the aircraft cockpit during ejection. It contains 128 data channels, which can transmit to the ground approximately 1,000 signals each second.

On the actual ATF aircraft it is planned to equip the pilot's ejection seat with a system of acceleration sensors, low-power thrusters and a microcomputer. It is reported that one of the channels will link its systems with the aircraft's radar which continuously maps the terrain and determines the aircraft's height above terrain. Specialists hope that the low-power thrusters will be able to ensure ejection-seat recovery from any attitude while on the ascending branch of its trajectory and stabilize it for deployment of the main parachute.

Display Screens

The manufacturer claims that new transparent screens for avionics visual devices—digital, plasma, and other displays—provide effective protection against electromagnetic radiation and radio-frequency emissions, as well as up to 95-percent transparency in displaying symbols or graphics. They are made of cast or laminated acrylic plastic with built-in (by means of homogenization) conducting screen in the form of a conductive grid. Grid shape, wire diameter, and conductive material can be selected for special applications. The acrylic backing is transparent or colored, and optical coatings can be applied to one or both sides. Specialists believe that special optical coatings and circular polarization are possible, as well as coatings to enhance scratch resistance. These screens can be mounted directly on the equipment with a conductive seating or in an aluminum mount.

Training Military Aircrews for Flying International Routes

90SV0004K Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 4, Apr 90 (signed to press 28 Feb 90) p 40

[Article, published under the heading "Flight Safety: Experience, Analysis, Problems," by Col A. Yudenko, deputy department chief, Unified Air Traffic Control System Interministerial Commission: "On International

Routes"; concluding part of two-part article; part one appeared in March 1990 issue of AVIATSIYA I KOSMONAVTIKA]

[Text] In conformity with established standards, aircraft crews on international flights use English for radio communications, utilizing the established radio communications phraseology in communications with air traffic control. Analysis of experience in preparing for and carrying out international flights by the crews of USSR Ministry of Defense transport aircraft indicated that it is necessary to have an interpreter on board, due to lack of adequate knowledge of English on the part of military aircrews. But this does not always make sense. Time is required for translation, which leads to delayed, and sometimes erroneous actions. This is particularly typical of such complex phases of flight as takeoff, approach and landing, as well as when abnormal or emergency situations arise.

It is also appropriate here to mention transport aircraft flights involved in relief efforts in the aftermath of the earthquake in Armenia. A large number of aircraft were airborne in a limited block of airspace; the crews of these aircraft were conducting radio communications in Russian and English. Lack of knowledge of English by aircraft crews prevented them from fully understanding the current air situation and presented certain difficulties in air traffic control. The current practice of studying English at flight schools and in air units training flight personnel to fly international routes fails to provide adequate knowledge of English radio communications phraseology. According to the civil aviation manual of flight operations, the captain, the first officer, the navigator, and the radio operator are to possess knowledge of English radio communications phraseology, while the flight engineer must possess sufficient knowledge of English for purposes of aircraft servicing and maintenance.

The Ministry of Civil Aviation, for example, has set up a special English language course for airmen, using modern training facilities, in order to meet this requirement. This is not being done at all, however, in Air Force line units. As a result international flights are possible only if additional persons with knowledge of English are added to the aircrew. This leads to greater expense. And the fact is that it is not even a matter of rubles but rather our overall knowledgeability and level of education.

It is essential radically to revise the ideology of training Ministry of Defense transport aircraft crews to fly international routes, so that the crews do not get into impasse situations, to put it mildly. One way to solve this problem is to provide classes in the English language as part of pilot ground training, to provide specially-equipped stations for listening to the radio communications of aircrews which have flown on international routes in the past, as well as to provide simulation of an international flight, using English, in order to test the crew's readiness for the flight. Initially money spent on maintaining flight-deck interpreters can be used to improve the quality of such training efforts.

I believe that it would be useful to permit aircraft crews (with the consent of air traffic control) to conduct radio communications in English on Soviet domestic air routes. As a rule ATC authorities will agree to this, since they too need the practice.

One of the problems which are not easily resolved when organizing international flights by Ministry of Defense aircraft is getting flight personnel certified for such flights and maintaining an adequate level of proficiency. The Manual of Flight Operations and Navigation Service Regulations of the Ministry of Civil Aviation state that crew members (captain, navigator, and radio operator) shall be permitted to fly an unfamiliar international air route unsupervised only after they have flown an accompanied check ride on that route (regardless of proficiency rating), and a navigator must fly at least two supervised familiarization runs on transoceanic routes.

Regulations applying to the crews of transport aircraft of the Ministry of Defense, however, stipulate that the aircraft commander and navigator shall be given check flights only when initially flying international routes. Subsequently, regardless of the difficulty of the air routes in question, the crew flies unsupervised. And as a rule radio operators are not required to pass a check ride. The reasoning for this is as follows: the crew contains a cockpit interpreter, who is capable of handling the required English-language radio communications.

Comparing both approaches to preparing crews for flying on international air routes, one can conclude that the level of preparation of Ministry of Defense crews is higher than that of civilian pilots. But that is not so.

Specially-selected Ministry of Civil Aviation crews regularly fly international routes. They carry on board all requisite documentation. The aircraft are equipped with radio navigation gear and flight instruments providing capability to maintain flight parameters with a high degree of accuracy and reliability. The crews of Ministry of Defense aircraft, however, fly international routes only sporadically, which prevents maintaining proficiency at an adequate level for making such flights. In addition, the equipment carried by Ministry of Defense transport aircraft is inferior to the equipment carried by civil aircraft.

A lack of regularity in flying international routes by military transport aircraft results in long periods between such flights, for it is practically impossible to plan and schedule flights on international air routes in advance. Everything depends on whether or not such flight assignments are required. And yet it is essential to establish rigorous record keeping and verification of performance of international flights by all crew members. Maximum intervals between such flights should be determined for each crew member, in conformity with the requirements of guideline documents. When such periods of time lapse, personnel should be given check rides on international routes under instructor supervision.

The crews of Ministry of Defense transport aircraft who fly international routes have plenty of problems. Many of them are solvable, however. Implementation of an aggregate of organizational and methodological measures, in combination with improving the quality of training and preparation of crews for international flights and the execution of such flights, will unquestionably help move things forward.

Listing of Soviet Space Launches in 1989

90SV0004L Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 4, Apr 90 (signed to press 28 Feb 90) pp 46-47

[Annotated table: "Table of Launches of Space Vehicles in the USSR in 1989"]

[Text]

Date of Launch	Name of Vehicle	Initial Orbital Parameters				Orbital Lifetime, Years (date of termination of operation)
		Orbital Period, min	Maximum Altitude, km	Minimum Altitude, km	Inclination, deg	
1	2	3	4	5	6	7
10 January	Kosmos 1987	11 h 15 min	19,145	19,111	64.8	1,000,000
10 January	Kosmos 1988	11 h 15 min	19,143	19,113	64.8	1,000,000
10 January	Kosmos 1989	11 h 16 min	19,160	19,118	64.8	1,000,000
12 January	Kosmos 1990	88.7	259	192	82.6	(11 Feb 89)
18 January	Kosmos 1991	90.4	401	216	70.0	(1 Feb 89)
26 January	Gorizont	24 h 33 min	36,582	36,433	1.3	1,000,000
26 January	Kosmos 1992	100.7	814	777	74.1	120
28 January	Kosmos 1993	89.9	382	180	64.8	(27 Mar 89)
10 February	Progress 40	88.8	266	193	51.6	(5 Mar 89)
10 February	Kosmos 1994	113.9	1,437	1,388	82.6	10,000
10 February	Kosmos 1995	113.9	1,434	1,399	82.6	10,000
10 February	Kosmos 1996	113.9	1,436	1,404	82.6	(10 Dec 89)
10 February	Kosmos 1997	114.0	1,441	1,404	82.6	10,000
10 February	Kosmos 1998	114.1	1,442	1,419	82.6	10,000
10 February	Kosmos 1999	114.2	1,445	1,417	82.6	10,000
10 February	Kosmos 2000	88.8	275	191	82.3	(2 Mar 89)
14 February	Kosmos 2001	11 h 49 min	39,342	613	62.8	15
14 February	Kosmos 2002	110.4	2,315	187	65.8	(15 Oct 89)
15 February	Molniya-1	11 h 38 min	38,937	486	62.9	12
17 February	Kosmos 2003	89.5	271	249	62.8	(3 Mar 89)
22 February	Kosmos 2004	105.1	1,031	993	83.0	1,200
28 February	Meteor-2	104.1	974	951	82.5	520
2 March	Kosmos 2005	89.7	347	197	62.8	(26 Apr 89)
16 March	Kosmos 2006	90.8	402	249	62.9	30 Mar 89)
16 March	Progress 41	88.7	260	193	51.6	(25 Apr 89)
23 March	Kosmos 2007	89.1	300	190	64.8	(22 Sep 89)
24 March	Kosmos 2008	114.5	1,496	1,407	74.0	9,500
24 March	Kosmos 2009	114.7	1,498	1,421	74.0	9,500
24 March	Kosmos 2010	114.9	1,498	1,437	74.0	9,500
24 March	Kosmos 2011	115.0	1,497	1,452	74.0	9,500
24 March	Kosmos 2012	115.2	1,497	1,469	74.0	9,500
24 March	Kosmos 2013	115.4	1,489	1,470	74.0	9,500
24 March	Kosmos 2014	115.6	1,494	1,485	74.0	9,500

Date of Launch	Name of Vehicle	Initial Orbital Parameters (Continued)				Orbital Lifetime, Years (date of termination of operation)
		Orbital Period, min	Maximum Altitude, km	Minimum Altitude, km	Inclination, deg	
1	2	3	4	5	6	7
24 March	Kosmos 2015	115.8	1,523	1,482	74.0	9,500
4 April	Kosmos 2016	104.9	1,026	973	82.9	1,200
6 April	Kosmos 2017	89.7	284	244	62.8	(19 Apr 89)
14 April	Raduga	24 h 34 min	36,558	36,488	1.4	1,000,000
20 April	Kosmos 2018	89.7	350	194	62.8	(19 Jun 89)
26 April	Foton	90.5	402	225	62.8	(11 May 89)
5 May	Kosmos 2019	89.5	268	247	62.9	(18 May 89)
17 May	Kosmos 2020	89.7	365	180	64.8	(15 Jul 89)
24 May	Kosmos 2021	89.3	303	204	70.0	(7 Jul 89)
25 May	Resurs-F	88.7	263	188	82.3	(17 Jun 89)
31 May	Kosmos 2022	11 h 15 min	19,154	19,120	64.9	1,000,000
31 May	Kosmos 2023	11 h 15 min	19,156	19,118	64.9	1,000,000
31 May	Kosmos 2024	11 h 15 min	19,154	19,119	64.9	1,000,000
1 June	Kosmos 2025	89.6	275	252	62.8	(15 Jun 89)
7 June	Kosmos 2026	104.8	1,022	969	82.9	1,150
8 June	Molniya-3	12 h 17 min	40,696	631	62.9	16
14 June	Kosmos 2027	94.6	522	484	65.9	5
16 June	Kosmos 2028	89.5	314	217	70.0	(6 Jul 89)
22 June	Raduga-1	24 h 32 min	36,592	36,486	1.5	1,000,000
27 June	Resurs-F	88.7	262	195	82.6	(11 Jul 89)
4 July	Nadezhda	104.9	1,026	979	83.0	1,200
5 July	Kosmos 2029	88.8	270	193	82.3	(19 Jul 89)
6 July	Gorizont	23 h 21 min	35,230	34,970	1.5	1,000,000
12 July	Kosmos 2030	89.7	373	177	67.2	(28 Jul 89)
18 July	Resurs-F	88.6	253	195	82.6	(8 Aug 89)
18 July	Kosmos 2031	89.0	283	200	50.5	(31 Aug 89)
20 July	Kosmos 2032	88.8	275	193	82.3	(3 Aug 89)
24 July	Kosmos 2033	92.3	436	410	65.0	2.8
25 July	Kosmos 2034	105.0	1,026	988	82.9	1,200
2 August	Kosmos 2035	88.8	268	191	82.6	(16 Aug 89)
15 August	Resurs-F	88.7	258	192	82.3	(14 Sep 89)
22 August	Kosmos 2036	89.6	275	248	62.8	(5 Sep 89)
23 August	Progress-M	88.5	235	191	51.6	(1 Dec 89)
28 August	Kosmos 2037	116.1	1,537	1,503	73.6	10,000
6 September	Soyuz TM-8	88.5	221	200	51.7	19 Feb 90)
6 September	Resurs-F	88.7	261	189	82.3	(22 Sep 89)
14 September	Kosmos 2038	113.8	1,434	1,388	82.6	9,700
14 September	Kosmos 2039	113.9	1,431	1,402	82.6	9,700
14 September	Kosmos 2040	113.9	1,438	1,404	82.6	9,700
14 September	Kosmos 2041	114.0	1,439	1,410	82.6	9,700
14 September	Kosmos 2042	114.1	1,443	1,413	82.6	9,700
14 September	Kosmos 2043	113.9	1,438	1,399	82.6	9,700

		Initial Orbital Parameters (Continued)				
Date of Launch	Name of Vehicle	Orbital Period, min	Maximum Altitude, km	Minimum Altitude, km	Inclination, deg	Orbital Lifetime, Years (date of termination of operation)
1	2	3	4	5	6	7
15 September	Kosmos 2044	89.3	294	216	82.3	(29 Sep 89)
22 September	Kosmos 2045	89.6	322	216	70.0	(2 Oct 89)
27 September	Molniya-1	11 h 42 min	38,960	650	62.8	14
27 September	Kosmos 2046	92.8	431	412	65.0	3
28 September	Interkosmos 24	116.0	2,497	511	82.6	48
28 September	Gorizont	23 h 54 min	35,866	35,641	1.3	1,000,000
3 October	Kosmos 2047	89.5	357	178	67.2	(22 Nov 89)
17 October	Kosmos 2048	89.4	270	248	62.8	(26 Oct 89)
25 October	Meteor-3	109.5	1,228	1,191	82.6	1,600
17 November	Kosmos 2049	89.0	291	189	64.8	
23 November	Kosmos 2050	11 h 49 min	39,342	613	62.8	15
25 November	Kosmos 2051	92.8	456	305	64.8	1.9
26 November	Kvant-2	89.8	339	221	51.6	
28 November	Molniya-3	12 h 16 min	40,600	649	62.8	16.5
30 November	Kosmos 2052	89.7	373	175	67.2	
1 December	Granat	98 h 14 min	201,424	1,998	51.5	
15 December	Raduga	24 h 35 min	36,591	36,511	1.5	1,000,000
20 December	Progress M-2	88.4	229	191	51.6	(9 Feb 90)
27 December	Kosmos 2053	95.2	548	527	73.6	8
27 December	Kosmos 2054	24 h 29 min	36,500	36,372	1.5	1,000,000

Comments

Kosmos is the designation of a series of satellites which are regularly launched (first launch 16 March 1962) from space launch facilities in the Soviet Union. Their scientific research program includes the following: —study of concentration of charged particles in the ionosphere, for the purpose of investigating propagation of radio waves, corpuscular streams [streams of particles] and low-energy particles, and the energy-state composition of the earth's radiation belts, in order to assess the radioactive hazard during extended space flights, the processes of adaptation to weightlessness, the primary composition of cosmic rays and variations in their intensity, the earth's magnetic field, high-frequency emissions from the sun and other celestial bodies, the upper atmosphere, and the effect of meteoric matter on the structural components of space vehicles; —investigations and experiments in space materials science, obtaining semiconductor materials, in conditions of local microgravity, with improved properties, as well as highly-pure biological preparations, study of the effect of weightlessness and cosmic radiation on the vital processes of living organisms, as well as the conduct of scientific and technical research and experiments for the benefit of various branches and sectors of the economy and international cooperation, including in the area of hydrology, cartography, geology, agriculture, and environmental science; —development of components and equipment for the GLONASS global satellite navigation system, which is being developed for the purpose of providing capability to determine the position of civil aircraft, merchant and fishing vessels, including downed aircraft and vessels in distress, experimental equipment for radiotelephone and radiotelegraph relay, satellite equipment, components and assemblies in various orbital operating conditions, including multiple-vehicle orbital flight, development of new types of data sensing and measuring equipment and methods of remote-sensing investigation of the earth's surface and atmosphere as well as the World Ocean; —obtaining current information for purposes of investigation of earth resources and the World Ocean, study of seismotectonic conditions for the benefit of industrial and civil construction, mapping of inaccessible regions of Antarctica, to increase accuracy of determination and prediction of the motion of space vehicles, geodetic and geophysical investigations.

Gorizont is a communications satellite designed to provide around-the-clock long-range radiotelephone and radiotelegraph communications and transmission of TV broadcasting to earth stations of the Orbita and Moskva systems, as well as for utilization in the Intersputnik international satellite communications system (the first of these satellites was launched on 19 December 1978).

Progress 40, 41, -M, and M-2 are unmanned supply craft designed to transport supplies in support of operation of manned orbital space stations.

Molniya-1 and -3 are communications satellites supporting long-range radiotelephone and radiotelegraph communications system operations, transmission of USSR Central Television programming to Orbita network earth stations, and for international cooperation (the first launch of a Molniya-1 satellite took place on 23 April 1965, while the first Molniya-3 satellite was launched on 21 November 1974).

Meteor-2 and -3 are weather satellites carrying equipment to obtain global imagery of cloud cover and the underlying surface in the visible and infrared regions of the spectrum, with both real-time transmission and image storage with subsequent transmission modes, as well as to provide continuous monitoring of penetrating radiation fluxes in near-earth space, and to obtain global data on vertical temperature distribution (the first of these satellites was launched on 11 July 1975).

Raduga-1 is a communications satellite with onboard multichannel relay equipment tasked with providing radiotelephone and radiotelegraph communications and transmission of TV programming (the first of these satellites was launched on 22 December 1975).

Foton is a satellite carrying equipment designed to obtain, in conditions of local microgravity, semiconductor materials with improved properties as well as highly-pure biologically-active preparations, and also to study the processes taking place in connection with this.

Resurs-F is a satellite carrying equipment designed to perform various-scale multizonal and spectrozonal photographic imagery for the purpose of continuing investigation of earth resources for the benefit of various branches and sectors of the USSR economy and for international cooperation. In addition, within the scope of this program, two Pion passive satellites were launched into orbit on 25 May and on 18 July 1989 [two satellites by each launch] to study the density of the upper atmosphere.

Nadezhda is a satellite carrying navigation system equipment tasked with determining the position of Soviet merchant and fishing vessels, as well as equipment to operate as part of the KOSPAS-SARSAT satellite search and rescue system, for search and rescue of ships in distress and downed aircraft.

Soyuz TM-8 is a manned spacecraft (crew: mission commander Aleksandr Stepanovich Viktorenko, flight engineer Aleksandr Aleksandrovich Serebrov) designed to deliver crew and supplies to the Mir space station.

Interkosmos 24 is a satellite piggybacking the Czechoslovak Magion-2 satellite. The launching of this satellite was organized within the scope of the Aktivnyy international scientific project, with the participation of Interkosmos program participating countries: Bulgaria, Hungary, the GDR, Poland, Romania, the USSR, and Czechoslovakia, for the purpose of conducting combined investigations of the processes of propagation of low-frequency electromagnetic waves in the earth's atmosphere and their interaction with charged particles in the radiation belts.

Kvant-2 is a specialized space station module designed to expand research and experiments as a component of the multipurpose permanent manned Mir space station complex.

Granat is a satellite observatory designed to investigate sources of X-radiation and soft gamma radiation in space. Onboard equipment was developed by specialists in the USSR, France, Denmark, and Bulgaria. Like investigations in the area of experimental high-energy astrophysics are also being conducted using the Soviet Kvant astrophysical module, which was boosted into orbit on 31 March 1987 and is operating as a component of the Mir complex, as well as the Japanese Ganga satellite.

A total of 95 vehicles were launched into orbit, including the following by a single launch vehicle: Proton (Kosmos 1987 - Kosmos 1989), Tsiklon (Kosmos 1994 - Kosmos 1999), Kosmos (Kosmos 2008 - Kosmos 2015), Proton (Kosmos 2022 - Kosmos 2024), and Tsiklon (Kosmos 2038 - Kosmos 2043).

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